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ABSTRACT

Three experiments investigated concept identification and recall of information as a function of four selected variables: concept complexity, method of instance presentation, stimulus exposure time, and conditions of recall. In all three experiments, retention was measured by the recall of instance values and the recall of instance categories. The number correct was used as the measure of concept identification. Subjects were selected from introductory educational psychology courses. The task in all three experiments was identical. Stimulus materials for the first two experiments consisted of geometric figures drawn on index cards, each figure containing a unique combination of four bivalued dimensions: in the third experiment, two additional dimensions were included. The subjects viewed a series of instances which uniquely defined a concept. After the last instance was displayed, subjects wrote their descriptions of the concept and recalled both the values and category of each presented instance. Results of Experiment 1 show increased recall under conditions of simultaneous presentation of all instances of a concept and under the condition permitting non-ordered recall. Concept Complexity was not related to concept identification or recall. In Experiment 2 it was found that increased exposure time improved recall of values and categories. Increased exposure time and random recall improved concept identification. Again, Concept Complexity was related to neither concept identification or recall. Experiment 3 found that both concept identification and recall were best under 15-second stimulus exposure duration. Category recall was found to be superior under the simultaneous method of presentation. (Author/RH)

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# RETENTION AND CONCEPT IDENTIFICATION AS FUNCTIONS OF CONCEPT COMPLEXITY, METHOD OF PRESENTATION, STIMULUS EXPOSURE TIME, AND CONDITIONS OF RECALL

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Report from the Project on Situational Variables and Efficiency of Concept Learning
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## PREFACE

One major program of the Wisconsin R and D Center for Cognitive Learning is Program 1 which is concerned with fundamental conditions and processes of learning. This Program consists of laboratory-type research projects, each independently concentrating on certain basic organismic or situational determinants of cognitive learning, but all attempting to provide knowledge which can be effectively utilized in the construction of instructional systems for tomorrow's schools.

Of critical importance to the field of human learning is the area of concept learning, an area in which most experimentation is designed primarily to reveal task or situational determinants of performance. Mr. Miller and Mr. Davis continue these empirical investigations and report the results of three laboratory experiments designed to determine the influence of concept complexity, stimulus exposure time, method of presentation, and conditions of recall on the performance of college subjects. Significantly, this research revealed that these variables affected recall more than concept identification by producing differential memory requirements.

Harold J. Fletcher
Director, Program 1

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## ABSTRACT

Three experiments were designed to investigate the effects of four selected variables upon the efficiency with which individuals identified concepts and recalled information used to present the concepts. Each experiment was designed such that each successive study included partial replications of its predecessor.

Subjects for each of the experiments were selected from introductory educational psychology courses and randomly assigned to each treatment condition. The experimental task consisted of displaying the minimum number of positive and negative instances (multi-dimensional, bivalued geometric figures) necessary to define the concept. After the last instance of each concept was displayed, *S*s were required to write the concept description (e.g. Two-red-circles) and to recall the values and category (positive or negative) of each instance used to present the concept.

In Experiment I, two levels of concept complexity (one or three values), two methods of stimulus presentation (simultaneous or successive), and two conditions of recall (unrestricted or random) were factorially combined in a 2 x 2 x 2 x 5 design. Ten *S*s were randomly assigned to each of the eight treatment conditions and tested in groups of five. Within each of the eight treatment conditions, *S* was tested on five concept problems. The essential findings of Experiment I were: (1) the number of values and categories recalled was greater when all instances of a concept were simultaneously presented; (2) the efficiency of identification and recall was increased under conditions permitting unrestricted recall; and (3) concept complexity was not found to differentially affect concept identification or recall of instance values or categories.

In Experiment II, two levels of complexity (one or three values relevant), two conditions of recall (unrestricted or random), and stimulus exposure times (5, 10, and 15 seconds) were factorially combined within a 2 x 2 x 3 design. Twelve *S*s were randomly assigned to one of the four complexity by recall treatment combinations and tested in groups of three. Within each treatment combination, *S* was tested on six concept problems, two within each stimulus exposure time. The essential findings of Experiment II were: (1) recall of values and categories was linearly related to increasing amounts of stimulus exposure time; and (2) concept complexity was not found to differentially affect either concept identification or recall of values and categories.

In Experiment III, two stimulus exposure times (5 and 15 seconds) and two methods of instance presentation were factorially combined in a 2 x 2 x 12 design. Twenty *S*s were randomly assigned to each of the four treatment conditions and tested in groups of five. Within each treatment condition *S* was tested on 12 concept problems. The essential findings of Experiment III were: (1) both concept identification and recall of instance values and categories were found superior under the 15-second stimulus exposure time; and (2) category recall was found superior when instances were simultaneously presented.

# I
# INTRODUCTION AND STATEMENT OF THE PROBLEM

Memory is both an inevitable and crucial phenomenon of learning and has, as such, been the object of experimental scrutiny since Ebbinghaus (1885). More recently, memory has been investigated with regard to its effect upon the learning of concepts. To date, although the literature on concept learning is extensive, few studies have treated the topic of memory explicitly. As a consequence, experimental evidence of a substantive kind has been sporadic and generally inconclusive, a state of affairs which led Hunt (1962) to remark "...everyone agrees that memory is important in concept learning, but no one has a clear idea of how it is important."

A current evaluation of the role of memory in concept learning is equally disappointing. Dominowski (1965), in a review of the topic, states that "...studies reported here have demonstrated to some degree the role of memory in the acquisition of concepts, but the precise identification of certain variables and their functional relationships with performance has not yet been achieved." There are a number of reasons which may be suggested for the lack of information concerning the relationship between memory and concept identification performance.

First, there are few studies which have dealt, either in a specific or general manner, with memory in concept identification. For example, of more than 500 studies in the area of concept learning listed by Klausmeier, Davis, Ramsay, Fredrick, and Davies (1965), less than ten were found to be relevant to the topic of memory.

A second problem, not unique to the literature on concept learning, concerns the extreme variability of experimental techniques and tasks employed. No one disputes the validity of varying experimental conditions in order to ultimately determine the generality of a given finding. The problem arises, however, when investigators, not understanding the idiosyncratic nature of two different tasks, employ similar variables and obtain conflicting results. In such cases, the determination of the effects of a given variable is obfuscated by the task conditions under which the variable was employed.

A third problem concerns the nature of the evidence regarding the role of memory in concept identification. For example, Bourne, Goldstein, and Link (1964) and Cahill and Hovland (1960) investigated concept identification as a function of the method (simultaneous or successive) by which instances were presented. Both studies found that the successive methods of presentation resulted in less efficient concept identification than did simultaneous methods of presentation. These investigators concluded that less efficient performance was a result of *S*s failing to recall previously presented information. This type of evidence, however, provides limited information regarding the role of memory in concept identification in that no direct retention measures were used.

Finally, researchers have not adequately assessed the relative importance of the retention of various classes of information present in concept learning tasks. The various classes of information which *S*s may retain in concept identification are:

1. Memory for the concept and its associated label once it has been learned.
2. Memory for the hypotheses which have been tested and those which remain to be tested.
3. Memory for the characteristics of the instances of the concept.
4. Memory for the category of the instance, i.e., whether or not a specific instance is a member of the concept.

In summary, these problems suggest two principle criteria for further experimentation in the area of memory and concept learning. First, experimentation should proceed within the confines of a standard task in order that the effects of the independent variables may

be attributed to their manipulation and not an artifact of the tasks in which they are employed. Second, direct measures of retention should be employed in order to determine the extent to which the various classes of information influence concept identification. These criteria were considered in designing the present studies.

Four independent variables were selected which have been found to influence performance in both concept identification and memory tasks. The variables were concept complexity (varied in terms of the number of dimensions relevant to the concept), method of instance presentation (simultaneous or successive presentation of instances), and stimulus exposure time (varied in terms of the number of seconds during which each instance of the concept was displayed), and conditions of recall (varied in terms of unrestricted or randomized recall order). The dependent variables employed were the number of concepts correctly identified, the number of instance characteristics (values) recalled, and the number of instance categories recalled. Within each experiment, two or three independent variables were factorially combined such that each successive study included partial replicatory conditions.

## II
## REVIEW OF THE LITERATURE

The present chapter is divided into four main sections. The first section is a review of those studies that have employed various retention intervals and measures to assess memory for concepts after learning. The second section reviews research relevant to the three main variables hypothesized to influence memory requirements during the task; namely, concept complexity, method of instance presentation, and stimulus exposure time. It will be noted that the main focus of the review concerns those studies which have used concept identification tasks in order to assess the effects of variables similar to those employed in the present experiments upon both acquisition and, where available, retention performance. The third section presents a recent theoretical model regarding the role of memory in concept identification. Finally, the last section is a summary of the review.

### MEMORY FOR CONCEPTS AFTER LEARNING

This section reviews experiments employing discrete retention intervals in order to test memory for concepts and/or their associated labels. Since the results of these studies are incidental to the present experiments, each will be reviewed only briefly.

Richardson (1956) employed a task in which *Ss* learned responses in the form of adjectives to four-unit noun lists. The standard retroactive interference (RI) paradigm was employed in which amounts of both original and interpolated learning were varied. Results, based upon a 24 hour relearning task, were as follows: 1) retention decreased as the degree of interpolated learning increased, 2) under conditions of no interpolation, complete recall of responses (adjectives) occurred, 3) the degree of original learning was ineffective in producing differential amounts of retention.

Employing a similar task and retention interval (24 hours), Underwood (1957) varied intralist similarity under conditions of massed or spaced practice. It was observed that as intralist similarity increased, the number of errors to a criterion of 10 trials increased irrespective of conditions of practice. However, minimal amounts of forgetting occurred under all conditions (absolute losses were not calculated due to difficulty in controlling for rehearsal and guessing).

Oseas and Underwood (1952) utilized multidimensional geometric figures to present concepts (consonant letters) within four conditions of distributed practice. Results indicated that varying the degree to which trials were separated did not significantly affect either the acquisition or retention of the concepts. Performance on the 24 hour relearning task, however, indicated very high retention.

A number of experiments have employed retention intervals in excess of 24 hours. Reed (1946a), employing a task in which one of a set of four words comprising each instance was paired with a nonsense syllable (concept), factorially combined two levels of "set to learn" and three retention intervals (one, three, and six weeks). Results of the recall tasks indicated that the number of prompts to correct solution was significantly reduced across all three retention intervals as indicated by savings scores ranging between 89-97%.

In a study using a similar task and stimulus materials, Reed (1946b) varied concept complexity by introducing four discrete amounts of irrelevant information. Relearning tasks were administered to separate groups within each of the four complexity conditions. Results suggested that, while savings occurred across both retention intervals, the duration of the interval did not differentially affect percentages of savings observed.

In a later study, Reed (1950), using the same task as previously described, varied the method of instance presentation (simultaneous or serial) together with instance list lengths of 24, 42, or 60 cards. The results were as follows: 1) method of presentation did not

differentially affect performance (number of prompts to correct solution) on either the acquisition or one week relearning task, 2) savings scores indicated an average of 95% of the concept labels (nonsense syllables) were retained.

A clarification is essential at this point. While concepts were transmitted via verbal or figural materials, the "to be retained" responses were often similar and few in number. In the studies that have been reported, these responses included simple verbal descriptions, nonsense syllables, consonant letters, and category labels. Consequently, it is difficult to assess the validity of the findings to non-laboratory situations where more complex concepts are learned. Partial evidence concerning this problem is offered by the following study.

Wittrock (1963) presented audiovisual programs on kinetic molecular theory to 80 first- and second-grade *Ss*. All *Ss* were individually run on eight consecutive school days. Immediately subsequent to the eighth instructional period, a multiple-choice test was administered. One year later, a similar test was given. Results indicated non-significant information losses as assessed by combined group mean scores (acquisition test = 26.99, retention test = 25.28).

In general, the evidence suggests that concepts, once learned, are highly resistant to forgetting. The validity of the conclusion is supported by the following conditions of the several experiments under which the effect occurred: The temporal duration of the retention interval (24 hours, one week, three weeks, six weeks, one year); the stimulus material used to present the concept (figural and verbal); the different "to be retained" responses (nonsense syllables, consonant letters, simple verbal descriptions, and complex semantic descriptions).

## HYPOTHESIZED MEMORY VARIABLES

### Concept Complexity

Archer (1966) has suggested that the one distinctive attribute of concepts is that they vary greatly in complexity. He has further suggested that complexity might be conceptualized as an n-dimensional space in which the various dimensions are different ways of manipulating the difficulty of identifying the concept.

One of these dimensions, about which exists a large amount of empirical evidence, has been operationally defined as the amount of relevant or irrelevant information present in the problem. Studies which have varied the number of irrelevant dimensions have obtained strikingly similar results. Using dimensionalized geometric stimuli, a number of investigators (Archer, 1962; Archer, Bourne & Brown, 1955; Bourne, 1957; Bourne & Haygood, 1960; and Brown & Archer, 1956) found that increased amounts of irrelevant information resulted in decreased performance. Moreover, these results hold across the following performance measures: time to criterion (Archer, 1962; Archer, Bourne & Brown, 1955; Bourne, 1957; and Brown & Archer, 1956), number of correct responses (Brown & Archer, 1956), and total number of responses to identification (Archer, Bourne & Brown, 1955).

Two studies have suggested a more precise relationship between performance and amount of irrelevant information. Brown and Archer (1962) found the number of correct responses to be an inverse linear function of increasing amounts of irrelevant information (0, 2, 4, or 6 irrelevant dimensions). Similarly, Bulgarella and Archer (1962) found that both number of trials and errors to solution increased linearly with increasing number of irrelevant dimensions (1, 2, and 3).

Concept complexity has also been defined in terms of the amount of information relevant to the concept. Employing six-dimensional geometric stimuli, Bourne (1963) investigated the effects of increasing numbers of attributes (one, two, and three) relevant to the concept. Results indicated that the number of trials required to solution increased as the amount of relevant information increased.

A variation of the experiment summarized above was employed by Bourne, Golstein and Link (1964). Subjects in this study responded with feedback to problems in which complexity was varied across one, two, and three relevant attributes. Results indicated that as complexity increased, total number of instances presented to solution, number of positive instances to solution, and number of negative instances to solution increased.

It is apparent that adding either relevant or irrelevant information increases the difficulty of solving conceptual problems. Walker and Bourne (1961) attempted to determine which of the two kinds of information produced relatively greater amounts of complexity. Although precise determination was obfuscated by a confounding factor (response system complexity increased as the number of relevant attributes increased), the investigators reported that the addition of a single unit of relevant

information produced a differentially greater amount of complexity than did the addition of a single unit of irrelevant information.

The extent to which concept complexity affects various performance measures has been clearly demonstrated by the previous studies cited. These same studies, however, have offered little substantive evidence suggesting the operation of underlying processes by which to account for the obtained results. The following studies contain evidence which suggests that memory factors may be, in part, determiners of complexity effects upon performance.

In a previously cited study, Reed (1946) embedded a "critical" word (instance of the concept) within lists of differing numbers of irrelevant words. The task consisted of associating series of critical words with a predetermined nonsense syllable. Trials-to-criterion for learning and relearning increased as the number of irrelevant instances increased.

A somewhat more direct test of memory requirements operating during the task was provided by Cahill and Hovland (1960). Investigating the effects of both concept complexity and method of instance presentation, these authors analyzed *Ss*' hypotheses in an attempt to determine the influence of both retention errors and perceptual errors upon identification performance. Memory errors were inferred from *Ss*' hypotheses inconsistent with previously presented information. Perceptual errors were inferred from hypotheses inconsistent with the immediately presented instance. The following results were reported: 1) a high proportion of errors were attributed to the failure of *Ss* to recall previously presented instances; 2) memory errors increased as more instances were presented; 3) subjects making fewer memory errors performed more efficiently on the concept identification task.

In a series of three experiments, Bourne, Goldstein, and Link (1964) employed a similar test of retention as that used by Cahill and Hovland. In the first experiment concept complexity (one, two, or three values relevant within a six dimensional array) and the number of previously displayed instances available for *Ss* inspection (0 to 5). The results indicated that performance (mean trials to solution) generally improved with increased stimulus availability and that the facilitative effect was more significant for problems of higher complexity. Results based upon two subsequent experiments additionally found a positive relationship between lesser numbers of available instances and memory errors (hypotheses incompatible with previously presented information). These results suggested that memory effects were, in part, a function of concept complexity; for simpler concepts where there is less information to store, performance was more efficient. However, for higher complexity concepts (more relevant information) acquisition performance was less efficient and memory errors more numerous.

The studies cited are in agreement that concept complexity can be manipulated by varying the amount of either relevant or irrelevant information and that the effect upon concept identification of increasing relevant information is greater than for corresponding increases in irrelevant. Moreover, several studies, employing indirect measures of retention, found evidence to suggest that the degree to which memory errors were commited negatively affected concept identification and that this relationship increased when the complexity of the concept increased.

The present studies will manipulate concept complexity by varying the amount of relevant information. Moreover, by employing both a retention and acquisition task, the present studies will offer a more substantive basis upon which to infer the effects of complexity upon memory requirements and the degree to which memory requirements are related to concept identification.

**Method of Presentation**

Underwood (1949), in a review of early concept learning literature suggested that "...concepts are more difficult to attain if *S* has to draw on memory to supply the characteristics defining the concept." This statement has perhaps provided the historical precedent for suggesting that the method by which instances are presented may be an important determiner of memory requirements operating during a concept identification task.

Reed (1950) analyzed both acquisition and memory data under both simultaneous and successive methods of instance presentation. Under the simultaneous condition all instances were immediately available for *Ss*' inspection whereas, under the successive condition, instances were displayed singly and withdrawn. Results indicated that neither method produced more efficient acquisition performance in terms of number of prompts required to solution. Using the same dependent measure, retention performance was slightly superior (though not significantly so) under the simultaneous method.

Two methods of presentation were compared in a similar situation by Hovland and

Weiss (1953). In the first experiment, instances were presented successively, whereas in the second experiment all instances were presented simultaneously. For sequences utilizing only negative instances, a higher proportion of concepts were solved under the simultaneous condition. For sequences containing only positive instances, the number of solutions was a maximum under both conditions allowing no differences to be indicated.

Cahill and Hovland (1960), in a study previously cited, investigated types of errors in a task which varied method of presentation (simultaneous or successive) across two levels of concept complexity. A slight variation of the usual simultaneous method was employed. As each new instance was exposed, it remained in view until problem solution occurred. Both number of correctly identified concepts and number of errors were used as dependent measures. Results indicated that identification performance was superior under the simultaneous condition for both complexity levels. Memory errors (responses incompatible with previously exposed information) were not found to be differentially affected by method of presentation.

Additional information concerning the effects of the number of intervening instances upon memory requirements was offered by Hunt (1961). In a series of two experiments, the number of instances intervening between the defining instance and test instances was varied 1, 3, 5, 7, 9, and 17. The results indicated that the number of errors committed in the list series was a positive linear function of the number of intervening instances—as the number of intervening instances increased the number of errors increased.

Kates and Yudin (1964) investigated the effects of three methods of presentation. In the simultaneous condition, each new instance and all previously exposed instances remained in view until problem solution occurred. In the successive condition, only the current instance was displayed simultaneously with each new instance. The results indicated that the successive condition produced more instances required to problem solution, more solution hypotheses compatible with the current instance displayed but less hypotheses compatible with previously exposed instances, and greater numbers of perceptual errors.

Finally, Bourne, Goldstein, and Link (1964) suggested that simultaneous and successive methods of instance presentation are but the extremes of what might be called the continuum of stimulus availability. Their initial study employed geometric stimuli varying in complexity (one, two, or three dimensions relevant) across six levels of stimulus availability in which either 0, 1, 2, 3, 4, or 5 preceding stimuli remained in view of *S*. The facilitative effect of increasing stimulus availability was found to increase as the complexity of the concept increased (the easier problems were solved so quickly that availability could have no effect). An additional finding suggested that performance (total instances, negative instances, and positive instances to solution) was a positive linear function of increasing numbers of available instances.

In a second experiment, Bourne et al. employed only three dimension relevant concepts together with 0, 4, 6, 8, or 10 available stimuli. Performance, as measured in the first study, again was dependent upon the number of instances available for inspection; greater numbers of available stimuli produced more efficient performance. An additional measure, developed by Cahill and Hovland (1960), involved comparing the compatibility of *S*s responses with currently and previously presented information. As found by Cahill et al., few perceptual errors were committed indicating that *S*s were perceiving current instances correctly and drawing appropriate information from them. The degree to which *S*s failed to recall previous instances (memory error), as measured by hypotheses incompatible with previously presented information, was a function of the differential availability of instances. In general, increasing the amount of information directly available for inspection increased the accuracy of the hypotheses generated as well as decreased the number of trials required to solution.

In general, the evidence indicates that *S*s proceed inefficiently through a concept learning task when solutions must be based upon retained information only. Memory requirements can be modified by varying the amount of information permanently available to *S*, and, therefore, information which does not have to be held in memory. When increasing amounts of information are removed, solutions become incomplete and inaccurate. Moreover, the amount of information available interacts with concept complexity in that simpler tasks are more easily solved in the absence of previously presented information than are tasks containing more critical dimensions.

### Stimulus Exposure Time

The above studies have indicated that information, to be efficiently utilized, must either

be sufficiently remembered or available for inspection. Whether stimuli are presented simultaneously or successively or under some intermediate condition, the temporal interval for inspection ought to be a critical variable in determining both acquisition and retention efficiency. Although it is generally accepted that increasing the time during which a fixed amount of information is to be learned increases both acquisition and retention, there has apparently been no study which has investigated the effects of stimulus exposure time within the confines of a concept identification task.

One study, however, employed a parameter which is analogous to stimulus exposure time. In their first and second studies, Bourne et al. allowed a maximum response time of 15 seconds to each new stimulus. The authors hypothesized that the significant departure from linearity occurring between 4 and 6 available stimuli might have been due to insufficient inspection time. In a third experiment, 0, 4, or 8 previous stimuli were available to *S*s under either a 15 second or unlimited response time. The results indicated that performance was an increasing linear function of stimulus availability only under conditions of unlimited response time. The largest difference between limited and unlimited response time occurred with eight stimuli available. The authors concluded that, while performance increased monotonically with increasing stimulus availability, a certain critical amount of time was essential for inspection of the stimuli and inferences drawn from the information. Presumably, this critical time was primarily dependent on the amount of information to be processed and the structural complexity of the problem.

## MATHEMATICAL MODELS OF CONCEPT IDENTIFICATION

Recently, Restle (1962) and Bower & Trabasso (1963) have developed mathematical models of concept identification that assume only limited memory during concept identification. The essentials of their position regarding the role of memory are as follows: 1) each concept identification task dictates a finite number of possible solutions or hypotheses; 2) a subject randomly samples and maintains a hypothesis until a negative instance is encountered; 3) in the case of a negative instance *S* returns the hypothesis to the set and randomly resamples (with replacement). Consequently the only information assumed to be retained during the task is the current "working hypothesis" and a few previous trials across which it has been correct.

There are two critical features of these assumptions, both of which concern memory. The first pertains to the assumption that *S*, upon encountering a negative instance, begins the strategy selection anew. The second critical feature concerns the assumption that *S* retains little of the information used to present the concept other than that which is embodied in the hypothesis. Both of these features will be critically examined here.

The sampling with replacement assumption essentially indicates that when an *S* receives a "wrong" or "no" on any given trial, he is placed back in an identical state to that which he was in at the onset of the problem. For example, if there were four possible hypothesis dictated by the problem, each hypothesis should have the same probability (.25) of recurring after a negative instance is encountered. Levine (1963) however, has shown that a "wrong" significantly reduces the probability of reoccurrence of a negatively reinforced hypothesis. Consequently, it may be suggested that *S*s remember previously incorrect hypotheses and thus fail to restate them on a later trial.

The assumption of limited memory for specific information presented during the task has also been investigated. Trabasso and Bower (1964) employed a standard reception paradigm (*E* controls instance presentation order) and a simulated concept identification task. Using six bivalued dimensions (one dimension relevant to the concept), successively presented instances, a five second stimulus exposure time, and randomized recall order, the investigators asked *S*s to identify the concept and then to recall the information presented during the task. The results indicated that an average of less than one value was recalled of the six presented within each instance. It was concluded that, in general, the evidence supported the assumption that *S*s retain little specific information presented during the task.

A major problem which results from assessing the validity of the limited memory assumption based on the study cited above concerns the single condition under which all *S*s were run. Precisely, the finding may have been the result of the short exposure duration, the successive method of presentation, or the amount of information presented both within each instance and in the concept, or any combination of the variables indicated above.

The present studies, by employing various levels of each of the variables indicated above,

in conjunction with a direct retention task, will allow a more adequate assessment of the effects of these variables upon memory in a concept identification task. In addition, by employing an acquisition measure, it will also be possible to obtain a better understanding of the relationship between memory for information presented during the task and concept identification.

## SUMMARY

Of the areas in which memory has been investigated, it is evident from this review that the main focus of attention has been upon memory for the concept and/or its associated label after learning. While the evidence suggested that concepts, once learned, are relatively permanent learning outcomes, this information is of comparatively little utility as regards the larger problem of memory effects during concept identification.

It is also evident from the previous studies cited, that the role of memory during concept identification tasks as a function of the three selected variables has been primarily inferred from measures which are related to acquisition. The primary measure reported was the hypothesis compatibility technique whereby the subject-generated hypothesis is validated in terms of previously presented information. Based upon this measure, the studies cited suggested that concept complexity, method of presentation, and stimulus exposure time may be important determiners of memory requirements during a concept identification task. It may be suggested, however, that this evidence was based upon a measure which confounds two possible sources of error—the failure to remember previously presented information and the failure to draw the appropriate inferences from previously presented information. It is hypothesized that the present study, by employing a direct measure of retention for the information presented, will be better able to assess the degree to which the variables employed differentially affect memory requirements during the task. It is also hypothesized that such information will produce a more substantive basis for inferences to be made concerning the importance of memory upon concept identification.

## III
## EXPERIMENT I

The purpose of the first experiment was to determine the extent to which concept complexity, method of presentation, and conditions of recall influence both concept identification and retention of instance values and categories. The specific hypotheses tested in the present experiment were as follows:

1) that the high complexity concepts would be more difficult to identify than low complexity concepts and that both values and categories would be recalled less efficiently for the high complexity conditions.
2) that the simultaneous method of presentation would result in more efficient concept identification and more efficient retention of both values and categories.
3) that under conditions of unrestricted recall both concept identification and the retention of both values and categories would be more efficient.

### METHOD

#### Subjects

The subjects (*S*s) participating in the present experiment were 19 males and 61 females ranging in age from 18 through 25 years (mean = 21.88 years). The 80 volunteer *S*s were currently enrolled in two introductory educational psychology classes which met during the 1966 summer session at the Madison campus, University of Wisconsin.

#### Experimental Materials

The stimulus materials used were geometric figures drawn on 3" x 5" index cards. Each figure was a unique combination of the following four bivalued dimensions:

number of figures ..... one or two
color of figure..... red or blue
size of figure ..... large or small
shape of figure..... triangle or rectangle

A total of 16 cards was required to produce figures using all possible combinations of the values specified above. Each of the cards was labeled YES in primary type. This designation was located at the bottom of the card. An identical set of 16 cards was constructed and each categorized NO in a similar fashion. The complete set of 32 instances was then laminated with matte-finished plastic to insure minimum surface reflectivity during display.

The construction of the problems was similar for both levels of complexity (one value or three values relevant). Each problem was uniquely defined by a total of five instances. The first card in each series was always labeled YES (positive instance). Between each of the subsequent instances, one or two dimensions was varied subject to the constraint that only one dimension could be varied for the first time. An additional constraint provided that negative instances (NO cards) occupy the second through fifth ordinal positions approximately equally often across problems. The problem structure, consequently, provided *S*s with the essential information to categorize a single dimension as relevant or irrelevant between any two adjacent instances.

Initially, eight problems were constructed within each of the two complexity levels. For the low complexity problems (one value relevant), each of the eight values was used as the concept for a different problem. For example, a low complexity concept might be "red" or "triangle." The high complexity problems (three values relevant) were constructed such that each value was used in combination as part of the concept approximately equally often. For example, a high complexity concept might be "two large triangles" or "small red rectangles." A complete description of the problems is found in Miller (1967).

The test booklets employed in the present experiment were of two types each corresponding to one of the two recall conditions. The unrestricted recall test booklet contained two response pages for each problem. The first page contained the word "concept" followed by a line upon which *S* wrote a description of the value(s) comprising the concept. The second response page contained a coded description of each instance. Recall was performed by *S* circling an appropriate description of each dimension (e.g. color: red or blue) and the category (yes or no). Under conditions employing random recall, six response pages for each problem were used. The concept description page was identical to that described above. The next five pages contained coded descriptions of single instances along with the designation of the presentation position of the instance. For example, an *S* might recall the instances in the following order: first, third, fourth, second, and fifth. Recall was performed in a manner identical to that indicated above.

The randomized recall test booklets were assembled using five randomly determined recall sequences. Five separate booklets were constructed such that each booklet contained a different order of the recall sequences used. This procedure resulted in each *S* recalling a different instance during any given response interval.

**Apparatus**

The apparatus employed in the present experiment consisted of a stimulus card display box and a Cousino, Model #7341, automatic tape sequencer. The display box essentially was a five-sided enclosure internally illuminated with three 75 watt showcase lamps. The back of the box contained a horizontal row of seven 2 3/4" x 4 3/4" apertures in which the instance cards were displayed. The experimenter (*E*) was seated in back of the box where were located switch panels governing room illumination level, pilot lights, a manual control for stimulus display lights, and the controls for the tape sequencer. The cards comprising a given problem were inserted into slotted moldings behind each aperture. The moldings were designed such that a total of ten instance cards could be inserted behind each aperture. This feature allowed initial preparation of two complete problems under the successive condition and a maximum of ten problems under the simultaneous condition.

**Procedure**

All *S*s in the present experiment were tested in groups of five. After reporting to the experimental room, *S*s were seated in a semicircle facing the display box. The *S*s were then instructed to fill in the subject information sheet at the front of the test booklet. After completion, the room lights were turned off and the instructions were played.

Two similar sets of instructions were employed; one set for each of the two recall conditions employed. The unrestricted recall instructions were as follows:

> The experiment in which you are involved today generally concerns itself with the question how do people learn and remember concepts. You will be shown a series of cards containing figures which can vary in several different ways. The shape of the figure will either be a triangle or a rectangle, its color red or blue, its size large or small, and its number one or two. A yes simply means that one or more of the characteristics of the figure are contained in the concept. A no simply means that one or more characteristics of the figure do not belong to the concept.
>
> (display lights on)
>
> The two cards which are now visible in the box contain all eight values of the four dimensions. The left card is described as one large red triangle. Its opposite, to the right, is described as two small blue rectangles.
>
> (display lights off)
>
> Your task will be to identify the value or values which we used to categorize the cards as either yes or no.
>
> Let's now work through two practice problems exactly as you will be doing during the experiment.
>
> (display cycle start)
>
> The first card is one small blue rectangle and it is a yes card. The second card is one small red rectangle and it is a yes card. The third card is two small red rectangles and it is a no card. The fourth card is one large red rectangle and it is a yes card. The fifth and last card contains one large red triangle and it is a yes card.
>
> (display cycle stop)

At my signal, turn the first page of your test booklet. In the space provided, write the value or values you think define the concept. After you have finished, turn this page and fill in completely the description of the cards as you remember them by circling one value for each dimension as well as the yes or no categories for each card. You may *not* refer back to your identification of the concept while doing this.

Please begin.

(90 second pause)

Stop.

The correct concept for this problem was one. For the first card, the number was one, size–small, color–blue, shape–rectangle, category–yes. Second card—one–small–red–rectangle–yes. Third card—two–small–red–rectangles–no. Fourth card—one–large–red–rectangle–yes. Fifth card—one–large–red–triangle–yes.

The second practice problem will be similar to the one you have just worked. Remember, when the room lights are illuminated at the end of the last card, begin to work on your answer sheets.

(145 second pause to view slides and complete responses)

Stop.

The correct concept for the second problem is two large blue. First card—two–large–blue–triangles–yes. Second card—one–large–blue–triangle–no. Third card—two–large–blue–rectangles–yes. Fourth card—two–small–blue–rectangles–no. Fifth card—two–small–red–triangles–no.

You have now worked on two practice problems. Your test problems will be similar to those you have just worked. Remember, begin working as soon as the room lights are illuminated, completely answer each page, and do not refer back to any previously completed page. Are there any questions?

The random recall instructions were identical to the instructions indicated above with the exception of the following paragraph:

At my signal, turn the first page of your test booklet. In the space provided, write the value or values you think define the concept. Then when the buzzer sounds, turn the page and write your description of the number of the card called for by circling one value for each dimension as well as the yes or no category. At each sound of the buzzer begin to work on the next card. As you work through the cards, you may *not* refer back to your identification of the concept or any previously completed card description.

After the instructions had been played, *S*s were allowed to ask questions concerning procedural elements of the task. The *E* responded by rereading relevant parts of the instructions. After all questions had been answered, the room was darkened and the experiment begun.

Four different programs, each corresponding to a unique recall by method condition, were employed. Subjects in the successive presentation group were presented instances one at a time. Each instance was displayed for ten seconds with a five second interstimulus interval. Within the simultaneous condition, all instances were displayed for 70 seconds. Immediately after all five instances were displayed, the room was illuminated and *S*s wrote their responses in the test booklets. Under both recall conditions, *S*s were allowed 15 seconds to write their descriptions of the concept. A buzzer (taped) was then sounded signaling a page turn. Under the unrestricted condition all instance descriptions were completed on a single page with a response time of 75 seconds allowed. Fifteen seconds were allotted for the completion of each random recall page.

The actual procedure for displaying the cards was determined by the method of presentation employed. For the successive condition, only the center aperture was used with the six remaining apertures covered by flat black index cards. The entire problem was inserted behind the center aperture and the instance cards withdrawn singly during each intersimulus interval. Within the simultaneous condition, all five instances comprising a problem were inserted into the five center apertures with the extreme right and left apertures covered. A flap was employed to cover and uncover all cards instantaneously.

The automatic tape sequencer was used to present the taped instructions, buzzer signals, and to control the lights within the display box. The light switching was accomplished via a nonaudible, high frequency signal which was recorded on the tape at 3 3/4 IPS. The accuracy of the sequencer was determined to be ± 1.25 seconds for a complete problem cycle.

Table 1. Experimental Design for Experiment I

| Recall | Unrestricted | | | | | | | | | | Random | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Method | Simultaneous | | | | | Successive | | | | | Simultaneous | | | | | Successive | | | | |
| Problems | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Complexity | | | | | | | | | | | | | | | | | | | | |
| 1 Value Relevant | $S_1$ . . . $S_{10}$ | | | | | | | | | | | | | | | | | | | |
| 3 Values Relevant | | | | | | | | | | | | | | | | $S_{71}$ . . . $S_{80}$ | | | | |

### Experimental Design

A 2 x 2 x 2 x 5 factorial design was employed with two levels of concept complexity (one value or three values relevant), two methods of presentation (simultaneous or successive), two conditions of recall (unrestricted or random), and five problems of which repeated measures were obtained. All *S*s were run in groups of five and randomly assigned to one of the eight cells comprising the design. Each group solved five problems selected at random within the appropriate complexity level. The experimental design for Experiment I is illustrated in Table 1.

The experiment consisted of each *S* solving five problems within a unique complexity by method by recall condition. Immediately subsequent to the experiment, test booklets were collected and *S*s cautioned against informing their classmates about the nature of the task.

### Treatment of the Data

The three dependent variables used to assess concept identification and retention were the number of concepts correctly identified, the number of instance values recalled, and the number of categories recalled. Each dependent variable was tested within a 2 x 2 x 2 x 5 repeated measures analysis of variance. The two conditions of recall were used in assessing concept identification so that any possible differential effects of conditions of recall upon subsequent identification of successive concepts could be determined. The probability of a Type I error was set at the .05 level. Effects significant beyond the .01 level were reported as such. Also, F values above 1 but not reaching the .05 level of significance were reported for the main effects. Where feasible, statistically significant effects were tested by post mortem means comparisons tests.

The procedure outlined by Box (1953) was employed to test all effects on which repeated measures occurred. The procedure reduces the degrees of freedom to $(a-1)\lambda$ and $(a-1)(n-1)\lambda$, where "a" is the number of levels of the repeated measure and $\lambda$ is set at $1/a-1$. All effects involving repeated measures were assessed by this conservative test. The result was indicated in each analyses of variance table by the use of "(c)" and the significance level at which the value occurred.

## RESULTS

### Concept Identification

Concept identification was evaluated on an all right–all wrong basis for each problem. A correct response was assigned a numerical value of "1" and an incorrect response a "0." For each of the eight treatment combinations, there were 10 *S*s each receiving five concept identification problems. Thus, scores could range from 0 to 5. The summary of the analysis of variance of the data is found in Table 2. The mean number of concepts identified for each treatment group is found in Table 3.

Table 2. Summary of Analysis of Variance of Identified Concepts

| Source | df | MS | F |
|---|---|---|---|
| Complexity (C) | 1 | .09 | < 1 |
| Recall (R) | 1 | 4.84 | 6.39* |
| Method (M) | 1 | 1.21 | 1.59 |
| C x R | 1 | 3.24 | 4.26* |
| C x M | 1 | .01 | < 1 |
| R x M | 1 | .64 | < 1 |
| C x R x M | 1 | .04 | < 1 |
| Ss (CRM) | 72 | .76 | |
| Ordinal Position (O) | 4 | .37 | 3.70** (c)NS |
| C x O | 4 | .07 | < 1 |
| R x O | 4 | .07 | < 1 |
| M x O | 4 | .29 | 2.90* (c)NS |
| CRO | 4 | .07 | < 1 |
| CMO | 4 | .16 | 1.60 |
| RMO | 4 | .19 | 1.90 |
| CRMO | 4 | .07 | < 1 |
| Ss (CRM)$^{O}$ | 288 | .10 | |
| Total | 399 | | |

* $p < .05$ ** $p < .01$

Table 3. Mean Number of Concepts Identified for all Treatment Groups

| Conditions of Recall | Concept Complexity | Method of Presentation | Ordinal Position of Problems 1 | 2 | 3 | 4 | 5 | Mean Number Method | Complexity |
|---|---|---|---|---|---|---|---|---|---|
| Unrestricted (.675) | 1-Value Relevant (.75) | Simultaneous (.78) | .70 | .80 | .70 | .80 | .90 | Simultaneous (.62) | 1-Value Relevant (.55) |
| | | Successive (.72) | .70 | .60 | .70 | .80 | .80 | | |
| | 3-Value Relevant (.60) | Simultaneous (.60) | .50 | .60 | .70 | .60 | .60 | | |
| | | Successive (.60) | .80 | .40 | .60 | .50 | .70 | | |
| Random (.455) | 1-Value Relevant (.35) | Simultaneous (.44) | .40 | .40 | .50 | .40 | .50 | Successive (.51) | 3-Value Relevant (.58) |
| | | Successive (.26) | .20 | .20 | .30 | .10 | .50 | | |
| | 3-Value Relevant (.56) | Simultaneous (.66) | .50 | .50 | .70 | .90 | .70 | | |
| | | Successive (.46) | .50 | .40 | .60 | .20 | .60 | | |
| | Ordinal Position | | (.537) | (.487) | (.600) | (.538) | (.662) | | |

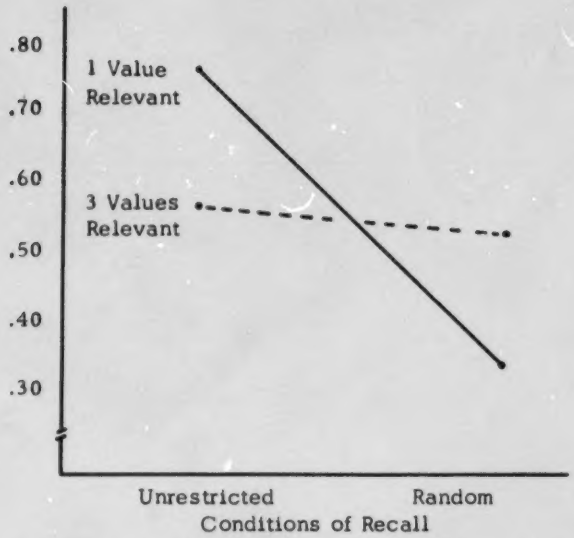


Figure 1. Mean Number of Concepts Identified as a Joint Function of Complexity and Recall Condition.

The effect of Ordinal Position was assessed as nonsignificant under the conservative test ($df$ = 1/79). The obtained F value (3.70), however, was such as to be proximate to the upper bound of the questionable region specified by the reduced and unreduced degrees of freedom. Inspection of Table 3 suggests the direction of the effect. As indicated by inspection of the five means involved in the effect due to Ordinal Position, there was no suggestion of a linear relationship between amount of practice and subsequent concept identification. However, it may be suggested that, in general, *Ss*' identified a greater number of concepts during later stages of practice.

The main effects of Complexity and Method were not significant. However, the method used to present the instances produced identification performance in the hypothesized direction; namely that the average number of identified concepts was greater under the simultaneous condition (.62) than that observed under the successive condition (.51). A statistically significant main effect was obtained for Conditions of Recall ($F$ = 6.39, $df$ = 1/72, $p$ < .05). The interaction of Complexity with Recall was also significant ($F$ = 4.26, $df$ = 1/72, $p$ < .05).

The mean number of identified concepts within the unrestricted and random conditions was .675 and .455, respectively. The result indicated that the recall procedure significantly affected the efficiency of concept identification. Concepts were identified less well by the group receiving the random recall treatment. This statement, however, must be qualified because of the significant interaction involving Complexity with Recall. This interaction is illustrated in Figure 1.

Subsequent $t$ tests performed on the means entering into the interaction indicated that concept identification under the high complexity condition was not significantly affected by conditions of recall ($t$ = 1.01, $df$ = 72). Performance on low complexity concepts, however, decreased significantly under the random recall condition ($t$ = 10.25, $df$ = 72, $p$ < .001).

**Instance Retention**

Retention of instances was evaluated on the basis of the total number of instance characteristics correctly recalled for each problem. This scoring system yielded a maximum of 20 correct responses for any given problem. The summary of the analysis of variance of the data is found in Table 4. The mean number of instance values retained within each treatment group is found in Table 5.

Complexity was not significant; however, the other main effects found to be statistically significant were Conditions of Recall ($F$ = 13.94, $df$ = 1/72, $p$ < .01) and Method of Instance Presentation ($F$ = 5.74, $df$ = 1/72, $p$ < .05). Significant sources of variation were also attributable to the second order interaction of Recall by Method by Ordinal Position

Table 4. Summary of Analysis of Variance of the Number of Instance Values Recalled

| Source | | df | MS | F |
|---|---|---|---|---|
| Complexity | (C) | 1 | .06 | < 1 |
| Recall | (R) | 1 | 280.56 | 13.94** |
| Method | (M) | 1 | 115.56 | 5.74* |
| C x R | | 1 | 48.30 | 2.40 |
| C x M | | 1 | 7.56 | < 1 |
| R x M | | 1 | 6.50 | < 1 |
| C x R x M | | 1 | 6.00 | < 1 |
| *Ss* (CRM) | | 72 | 20.13 | |
| Ordinal Position (O) | | 4 | 7.05 | 1.31 |
| C x O | | 4 | 12.33 | 2.29 |
| R x O | | 4 | 11.94 | 2.22 |
| M x O | | 4 | 7.51 | 1.39 |
| CRO | | 4 | 4.51 | < 1 |
| CMO | | 4 | 2.94 | < 1. |
| RMO | | 4 | 21.77 | 4.04** (c)* |
| CRMO | | 4 | 13.39 | 2.48* (c)NS |
| *Ss* (CRM)O | | 288 | 5.39 | |
| Total | | 399 | | |

*p < .05 **p < .01

Table 5. Mean Number of Values Recalled for all Treatment Groups

| Conditions of Recall | Concept Complexity | : Method of Presentation | Ordinal Position of Problems 1 | 2 | 3 | 4 | 5 | Mean Number Method | Complexity |
|---|---|---|---|---|---|---|---|---|---|
| Unrestricted (17.25) | 1-Value Relevant (17.61) | Simultaneous (18.28) | 18.8 | 18.9 | 18.2 | 17.7 | 17.8 | Simultaneous (16.95) | 1-Value Relevant (16.43) |
| | | Successive (16.94) | 17.4 | 17.5 | 15.8 | 17.6 | 16.4 | | |
| | 3-Value Relevant (16.89) | Simultaneous (17.04) | 18.0 | 17.0 | 17.1 | 16.0 | 17.1 | | |
| | | Successive (16.74) | 17.0 | 16.5 | 17.8 | 17.4 | 15.0 | | |
| Random (15.58) | 1-Value Relevant (15.24) | Simultaneous (15.92) | 15.7 | 15.8 | 13.3 | 17.9 | 16.9 | Successive (15.88) | 3-Value Relevant (16.40) |
| | | Successive (14.56) | 15.1 | 12.4 | 15.5 | 14.4 | 15.4 | | |
| | 3-Value Relevant (15.91) | Simultaneous (16.56) | 17.1 | 16.4 | 16.8 | 17.2 | 15.3 | | |
| | | Successive (15.26) | 15.3 | 14.5 | 15.9 | 15.0 | 15.6 | | |
| | Ordinal Position | | (16.08) | (16.13) | (16.30) | (16.65) | (16.19) | | |

($F = 4.04$, $df = 4/288$, $p < .01$) and the third order interaction of Complexity by Recall by Method by Ordinal Position ($F = 2.4$, $df = 4/288$, $p < .05$). Under the conservative test, the second order interaction was again found to be significant ($df = 1/79$).

The significant source of variation attributable to the conditions under which recall occurred was observed to be in the expected direction. The mean number of instance values retained was 17.25 and 15.58 under the unrestricted and random recall conditions respectively. An inspection of Table 5 reveals the stability of the effect in that no reversals between the unrestricted and random conditions were found across all major treatment groups.

Method of Instance Presentation was also found to significantly affect the number of instance values recalled. The means entering into the effect were 16.95 and 15.88 for the simultaneous and successive condition respectively. Again, the absence of crossover effects across all major treatment groups suggests the stability of the effect. This result indicates that *Ss* were better able to retain the values of the instances under conditions allowing maximum stimulus availability throughout problem presentation.

The effects of both recall and method must be qualified, however, under conditions involving practice as evidenced by the significant interaction of recall by method by ordinal position of problems. The 20 means entering into the interaction are found in Table 6. Figure 2 graphically illustrates the effect.

Table 6. Mean Number of Instance Values Recalled as a Joint Function of Recall by Method by Ordinal Position

| | Simultaneous | | | | | Successive | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| O.P. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Un | 18.40 | 17.95 | 17.65 | 16.85 | 17.45 | 17.20 | 17.00 | 16.80 | 17.50 | 15.70 |
| Rd | 16.40 | 16.10 | 15.05 | 17.55 | 16.10 | 15.20 | 13.45 | 15.70 | 14.70 | 15.50 |

O.P. = Ordinal Position
Un = Unrestricted
Rd = Random

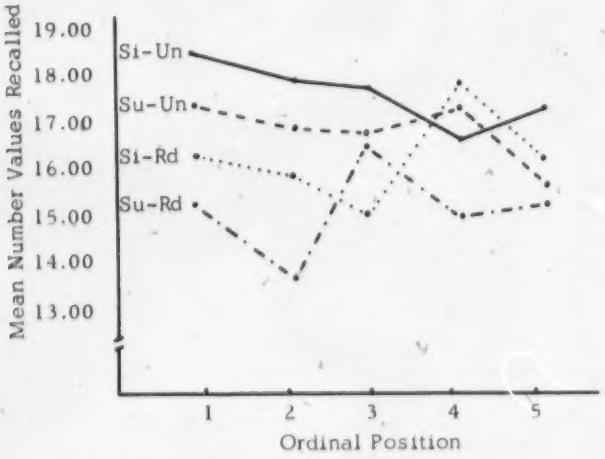


Figure 2. Mean Number of Instance Values Retained as a Joint Function of Method, Recall, and Ordinal Position

Table 7. Analysis of Variance for Simple Ordinal Position (OP) Effects in RMO Interaction

| Source | df | MS | F |
|---|---|---|---|
| R x M for OP | 1 | 00.00 | < 1 |
| R x M for $OP^1$ | 1 | 14.45 | 2.08 |
| R x M for $OP^2$ | 1 | 11.25 | 1.70 |
| R x M for $OP^3$ | 1 | 61.25 | 11.36** |
| R x M for $OP_5^4$ | 1 | 6.61 | 1.24 |
| *Ss* $(CRM)^{OP}$ | 288 | 5.39 | |

** $p < .01$

Table 8. Summary of Analysis of Variance of Correct Category Responses

| Source | | df | MS | F |
|---|---|---|---|---|
| Complexity | (C) | 1 | .12 | < 1 |
| Recall | (R) | 1 | 9.30 | 4.01* |
| Method | (M) | 1 | 25.50 | 10.99** |
| C x R | | 1 | 1.82 | < 1 |
| C x M | | 1 | .90 | < 1 |
| R x M | | 1 | .02 | < 1 |
| C x R x M | | 1 | .72 | < 1 |
| *Ss* (CRM) | | 72 | 2.32 | |
| Ordinal Position | (O) | 4 | 1.15 | 1.59 |
| C x O | | 4 | 1.87 | 2.60* (c)NS |
| R x O | | 4 | .79 | 1.09 |
| M x O | | 4 | .03 | < 1 |
| CRO | | 4 | .44 | < 1 |
| CMO | | 4 | .93 | 1.29 |
| RMO | | 4 | .26 | < 1 |
| CRMO | | 4 | .34 | < 1 |
| *Ss* $(CRM)^O$ | | 288 | .72 | |
| Total | | 399 | | |

* $p < .05$ ** $p < .01$

Inspection of Figure 2 indicates that recall of instances generally decreased within the early stages of practice. Major reversals occurred, however, within both treatment combinations involving random recall at the later stages of practice. A simple effects analysis of variance was used to test the differences between the Recall by Method means at each ordinal position. The summary of the analysis is found in Table 7.

The variability in the recall of instances significantly increased within the fourth ordinal position ($F = 11.36$, $df = 1/288$, $p < .01$). A subsequent Newman-Keuls procedure (Winer, 1962) was used to test the four means entering into the effect. Significantly fewer instances were recalled within the successive-random group as compared with the remaining three groups ($p < .01$). Thus, the interaction was primarily a function of the greater performance variability associated with ordinal position four. Any further interpretation, however, must await additional evidence on the influence of practice effects upon the task variables employed in the present study.

### Category Retention

Retention of categories was evaluated on the basis of the total number of categories recalled for each problem. A single category response specified each instance as a positive (YES) or negative (NO) example of the concept. The scoring system resulted in a maximum of five correct responses for each problem. Table 8 summarizes the analysis of variance of the

Table 9. Mean Number of Categories Recalled for all Treatment Groups

| Conditions of Recall | Concept Complexity | Method of Presentation | Ordinal Position of Problems 1 | 2 | 3 | 4 | 5 | Mean Number Method | Complexity |
|---|---|---|---|---|---|---|---|---|---|
| Unrestricted (4.48) | 1-Value Relevant (4.53) | Simultaneous (4.88) | 4.8 | 5.0 | 4.8 | 4.8 | 5.0 | Simultaneous (4.58) | 1-Value Relevant (4.53) |
| | | Successive (4.18) | 4.5 | 4.6 | 3.6 | 4.2 | 4.0 | | |
| | 3-Value Relevant (4.43) | Simultaneous (4.60) | 4.9 | 4.6 | 4.4 | 4.6 | 4.5 | | |
| | | Successive (4.26) | 4.6 | 4.1 | 4.4 | 3.9 | 4.3 | | |
| Random (4.18) | 1-Value Relevant (4.09) | Simultaneous (4.34) | 4.2 | 4.3 | 3.9 | 4.5 | 4.8 | Successive (4.08) | 3-Value Relevant (4.35) |
| | | Successive (3.84) | 3.7 | 3.7 | 3.5 | 4.3 | 4.0 | | |
| | 3-Value Relevant (4.26) | Simultaneous (4.50) | 4.8 | 4.4 | 4.5 | 4.3 | 4.5 | | |
| | | Successive (4.02) | 4.1 | 3.9 | 4.1 | 3.7 | 4.3 | | |
| | Ordinal Position | | (4.45) | (4.33) | (4.15) | (4.29) | (4.43) | | |

Table 10. Summary of Analyses of Variance for Experiment I

| Main Effects | | Dependent Variables: Concept Identification F | Concept Identification Direction of Mean | Instance Retention F | Instance Retention Direction of Mean | Category Retention F | Category Retention Direction of Mean |
|---|---|---|---|---|---|---|---|
| Concept Complexity | (C) | < 1 | | < 1 | | < 1 | |
| Conditions of Recall | (R) | 6.39* | Un > Rd | 13.94** | Un > Rd | 4.01* | Un > Rd |
| Method of Presentation | (M) | | Si > Su | 5.74* | $S_i > S_u$ | 10.9** | $S_i > S_u$ |
| Ordinal Position | (O) | | | | | | |
| **Interactions** | | **F** | | **F** | | **F** | |
| C x R | | 4.26* | | | | < 1 | |
| C x M | | < 1 | | < 1 | | < 1 | |
| R x M | | < 1 | | < 1 | | < 1 | |
| C x O | | < 1 | | | | | |
| R x O | | < 1 | | | | | |
| M x O | | | | | | < 1 | |
| C x R x M | | < 1 | | < 1 | | < 1 | |
| C x R x O | | < 1 | | < 1 | | < 1 | |
| C x M x O | | | | < 1 | | | |
| R x M x O | | | | 4.04* | | < 1 | |
| C x R x M x O | | < 1 | | | | < 1 | |

* $p < .05$ ** $p < .01$

category data. Table 9 indicates the mean number of categories recalled within each treatment group.

Complexity was not significant. Statistically significant main effects were Conditions of Recall ($F = 4.01$, $df = 1/72$, $p < .05$) and Method of Instance Presentation ($F = 10.99$, $df = 1/72$, $p < .01$). No interaction effects were found significant.

The mean numbers of categories recalled under the unrestricted and random condition were 4.48 and 4.18 respectively. The result was in the expected direction and indicated that categories were better retained when unrestricted rather than random recall procedures were employed. Inspection of the two means, however, indicated that recall of categories was very high within both conditions of recall. This result was not unexpected in view of the relatively low information load within either of the two problem complexities. In any problem, the number of negative instances was identical to the number of relevant values comprising the concept. Consequently, for low complexity concept problems (one value relevant), only the presentation position of the NO instance insured maximum category recall. Conversely, for high complexity problems (three values relevant), the recall of the presentation positions of the two YES instances provided the sufficient condition for maximum category recall. The failure to find that the complexity of the problem significantly affected category recall offers partial support for the tenability of this explanation.

The main effect of Method of Instance Presentation was also found to significantly affect category retention recalled. The mean number of categories recalled under the simultaneous and successive conditions was 4.58 and 4.08 respectively. Retention, therefore, was more efficient under the simultaneous method of presentation which allowed maximum instance availability.

## SUMMARY

A summary of the three main analyses of variance is found in Table 10. As hypothesized, the simultaneous method of presentation and unrestricted recall conditions resulted in superior recall of both instance values and categories. Although not statistically significant, the simultaneous method of presentation was also related to more efficient concept identification. This lends some support to the larger hypothesis underlying these studies that decreasing memory requirements increases concept identification.

As noted in Table 10, the unrestricted condition of recall was also associated with more efficient concept identification. This result suggests that permitting *S* to recall instance values and categories without any recall order imposed by *E* facilitated identification. Contrary to prediction, the complexity of the concept failed to differentially affect either concept identification or the recall of instances and categories. This unexpected finding may have been due, in part, to the stimulus exposure interval (10 seconds) which was employed in the present experiment. The subsequent experiment was designed to investigate this tentative explanation more fully.

The preceding summary of the results of Experiment I is treated in greater detail in the final chapter of the report and after considering the results from the next two experiments.

## IV
## EXPERIMENT II

In the preceding experiment, both Method of Presentation and Conditions of Recall generally produced performance differences in the hypothesized directions. Concept Complexity, however, failed to differentially affect either concept identification or the recall of values and categories. The present experiment was designed, therefore, to determine whether complexity was related to the temporal duration employed to present the instances of the concept. For the purpose of not confounding exposure duration and method, both of which affect the degree to which stimuli are available for *S*'s inspection, only the successive method of presentation was employed together with stimulus exposure times (SET) of 5, 10, and 15 seconds.

The hypotheses tested in the present experiment were as follows:

1) that the high complexity concepts would be more difficult to identify than low complexity concepts under successively lower SETs of 15, 10, and 5 seconds.
2) that the recall of instances and categories would be less efficient under successively lower SETs of 15, 10, and 5 seconds.
3) that concept identification and recall of instance values and categories would be less efficient under conditions employing random recall procedures.

### METHOD

#### Subjects

Fourteen males and 34 females, ranging in age from 18 through 25 years (mean = 20.98 years), participated in the present experiment. The 48 Ss were selected on a voluntary basis from two introductory educational psychology classes which met during the first semester, 1966-1967, at the Madison Campus, University of Wisconsin.

#### Experimental Materials

The stimulus materials and populations of concepts to be identified were identical to those used in the first experiment. Initially, one problem was randomly selected from each complexity level and used as a demonstration problem in the instructions. The remaining seven problems within each complexity level were used as independent populations from which were drawn at random six problems for each group of three *S*s. The one restriction employed was that the problems were selected approximately equally often within the eight sequences of each complexity level.

The test booklets were identical to those used in Experiment I. The addition of one problem to the experimental series, however, required an appropriate increase in the number of response pages in both the unrestricted and random booklets.

The same apparatus was again employed except for minor modifications required as a result of all instances being successively displayed, a single demonstration problem accompanying the instructions, and the presentation of six rather than five experimental problems. These modifications primarily affected the preparation of the automatic sequencing tapes rather than resulting in any changes to the apparatus proper.

#### Experimental Design

The design, illustrated in Table 11, was a 2 x 2 x 3 factorial with two levels of concept complexity (one or three relevant values) and two recall conditions (unrestricted or random), with repeated measures across three stimulus exposure times (5, 10, or 15 seconds). All *S*s were run in groups of three and randomly assigned to one of the four main complexity by recall treatment combinations. Each *S* solved six problems, two within each SET interval. Since two problems occurred within each SET interval, the six discrete exposure

Table 11. Experimental Design

| Conditions of Recall | Unrestricted | | | | | | Random | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stimulus Exposure Time | 5 | | 10 | | 15 | | 5 | | 10 | | 15 | |
| Ordinal Position | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 |
| Complexity | $S_1$ | | | | | | | | | | | |
| | . | | | | | | | | | | | |
| | . | | | | | | | | | | | |
| 1 Value Relevant | . | | | | | | | | | | | |
| | . | | | | | | | | | | | |
| | . | | | | | | | | | | | |
| | $S_{12}$ | | | | | | | | | | | |
| | | | | | | | $S_{17}$ | | | | | |
| | | | | | | | . | | | | | |
| | | | | | | | . | | | | | |
| 3 Values Relevant | | | | | | | . | | | | | |
| | | | | | | | . | | | | | |
| | | | | | | | . | | | | | |
| | | | | | | | $S_{48}$ | | | | | |

durations were randomly assigned to problems. The single restriction employed was that each of the six exposure durations occupy a given ordinal position approximately equally often within any complexity by recall treatment cell.

**Experimental Procedure**

All *S*s in the present experiment were tested in groups of three. The *S*s were seated in a semicircle in front of the stimulus display box and instructed to complete the subject information page. After completion, the room lights were turned off and the instructions were played.

The instructions contained the same procedural information as those used in Experiment I. The major modification introduced was the use of only one practice problem within each set of instructions. The reduction was made based upon a pilot study which indicated that a second practice problem did not further facilitate *S*'s understanding of the experimental procedure or the postpractice performance level. The instructions were again taped and the practice problem presented corresponded to the complexity by recall condition for which it was employed. Finally, the practice problem within each complexity level was presented via the successive method of presentation and each instance was displayed for ten seconds.

The recall procedure was also similar to that employed in the first experiment. Immediately after the presentation of the last instance of any problem, the room lights were turned on and *S*s were given 15 seconds to complete their descriptions of the concept. Within the unrestricted recall treatment condition, a taped buzzer was sounded signaling *S*s to begin the recall task. Seventy-five seconds was allowed for recall task completion. Subjects recalling the instance descriptions in a random order were allowed 15 seconds for each instance description. A buzzer was used to signal each page turn. After the six problems were completed, the test booklets were collected and *S*s cautioned against informing their classmates about the task.

**Treatment of the Data**

The three dependent variables used to assess *S*'s performance on the task were concept identification score, retention of instance values, and retention of instance categories. The scoring procedure differed from the previous experiment in that the problems were summed within each SET and used as the basic data. Each dependent variable was tested within a 2 x 2 x 3 repeated measures analysis of variance. In all the analyses the probability of a Type I error was set at the .05 level. Effects

Table 12. Summary of Analysis of Variance of Correct Concept Responses

| Source | df | MS | F |
|---|---|---|---|
| Complexity (C) | 1 | 0.00 | < 1 |
| Recall (R) | 1 | .03 | < 1 |
| SET (S) | 2 | .88 | 3.37* (c)NS |
| C x R | 1 | 0.00 | < 1 |
| C x S | 2 | .15 | < 1 |
| R x S | 2 | .89 | 3.35* (c)NS |
| C x R x S | 2 | .14 | < 1 |
| Ss (C x R) | 44 | 1.63 | |
| Ss (C x R)SET | 88 | .26 | |
| Total | 143 | | |

*p < .05

Table 13. Mean Number of Concept Identified for all Treatment Groups

| Conditions of Recall | Concept Complexity | Stimulus Exposure Time (SET) 5 Seconds | 10 Seconds | 15 Seconds | Complexity Means | Recall Means |
|---|---|---|---|---|---|---|
| Unrestricted | 1-Value Relevant (1.056) | .92 | 1.33 | .92 | 1-Value (1.069) | Unrestricted (1.055) |
| | 3-Values Relevant (1.056) | .92 | 1.33 | .92 | | |
| Random | 1-Value Relevant (1.083) | .83 | 1.17 | 1.25 | 3-Values (1.069) | Random (1.083) |
| | 3-Values Relevant (1.083) | 1.08 | 1.00 | 1.17 | | |
| SET Means | | (.938) | (1.208) | (1.063) | | |

significant beyond the .01 level were reported as such. Also, F values for main effects greater than 1 but not significant at the .05 level are indicated. Where feasible, statistically significant effects were tested via post mortem means comparisons tests and/or by orthogonal polynomial analyses.

## RESULTS

### Concept Identification

Concept identification was assessed in terms of an all right–all wrong basis within each problem. A correct concept description was assigned a numerical value of "1" and an incorrect description a "0." The data entering into the analysis was based upon the total number of concepts identified by S with each SET level. Consequently, the maximum total concept score attainable was six, two within each of three SET levels and within each treatment combination. The summary of the analysis of variance of correct concepts is found in Table 12. Table 13 indicates the mean performance for two problems within each treatment condition.

Table 14. Mean Number Correct Concept Identification Responses for the SET x Recall Interaction

| Conditions of Recall | SET | | |
|---|---|---|---|
| | 5 Seconds | 10 Seconds | 15 Seconds |
| Unrestricted | .92 | 1.33 | .92 |
| Random | .96 | 1.09 | 1.21 |

Table 15. Summary of Analysis of Variance of the Number of Instance Values Recalled

| Source | df | MS | F |
|---|---|---|---|
| Complexity (C) | 1 | 9.00 | < 1 |
| Recall (R) | 1 | 235.11 | 3.97 |
| C x R | 1 | 53.77 | < 1 |
| *Ss* (C x R) | 44 | 59.12 | |
| SET (S) | 2 | 149.77 | 12.10** (c)** |
| Linear 1 | | 290.24 | 23.46** |
| Quadratic 1 | | 9.30 | < 1 |
| C x S | 2 | 16.52 | 1.33 |
| R x S | 2 | 3.00 | < 1 |
| C x R x S | 2 | 15.43 | 1.25 |
| *Ss* (C x R)SET | 88 | 12.37 | |
| Total | 143 | | |

** $p < .01$

As assessed by the conservative test (*df* = 1/44), neither SET nor the Recall by SET interaction was found significant. However, due to the fact that the effects under consideration were of interest within the present experiment, an additional assessment involving Box's approximate test (Greenhouse & Geisser, 1959) was applied. The test involved the calculation of the variance-covariance matrix across the three levels of the repeated measure SET. From the matrix ($\Sigma$) was computed $\epsilon = p^2(\bar{\sigma}_{tt} - \bar{\sigma}_{..})^2/(p-1)(\Sigma\Sigma\sigma^2_{ts} - 2p\Sigma\sigma^{-2}_{t.} + p^2\sigma^{-2}_{..})$; where p is the number of levels under the repeated measure, $\sigma_{ts}$ are the elements of the matrix $\Sigma$, $\bar{\sigma}_{tt}$ is the mean of the diagonal terms, $\bar{\sigma}_{t.}$ is the mean of the tth row (or tth column), and $\bar{\sigma}_{..}$ is the grand mean. The value calculated for $\epsilon$ was .79 which entered in as the multiplier of both the numerator and denominator of the unreduced degrees of freedom (*df* = 2/88). The critical F value (3.59) was interpolated from the resultant degrees of freedom specified by $\epsilon$(*df* = 1.58/69.52). Again, both effects approached but did not exceed the critical F value.

Additional information, however, may be obtained by inspection of the means of the two questionable sources of variation. The three means entering into the SET main effect were .938, 1.208, and 1.063 for the 5, 10, and 15 second conditions, respectively. Thus, there was some indication that more concepts were identified under the two conditions allowing exposure intervals in excess of five seconds although apparently the function relating SET to concept identification was not primarily linear.

The interaction of SET with Recall is indicated in Table 14 and is of further utility in more precisely determining the general effect of SET upon concept identification. It is apparent that a curvilinear function best describes the effect of SET upon the mean number of concepts identified for the unrestricted recall condition. Conversely, under the random recall condition, the mean number of identified concepts tended to increase with increasing amounts of exposure time. Thus, it may be seen that, in general, increasing the time during which instances were displayed facilitated concept identification although the

Table 16. Mean Number of Values Recalled for all Treatment Groups

| Conditions of Recall | Concept Complexity | Stimulus Exposure Time (SET) 5 Seconds | 10 Seconds | 15 Seconds | Complexity Means | Recall Means |
|---|---|---|---|---|---|---|
| Unrestricted | 1-Value Relevant (31.97) | 29.8 | 32.4 | 33.7 | 1-Value (30.08) | Unrestricted (31.61) |
| | 3-Values Relevant (31.25) | 29.0 | 31.7 | 33.1 | | |
| Random | 1-Value Relevant (28.19) | 26.0 | 29.9 | 28.7 | 3-Values (30.58) | Random (29.06) |
| | 3-Values Relevant (29.92) | 28.8 | 29.0 | 32.0 | | |
| SET Means | | (28.40) | (30.75) | (31.85) | | |

facilitative effect was not apparent for exposure durations beyond ten seconds within the unrestricted recall condition.

**Instance Retention**

The scoring system used to assess instance retention performance was similar to that employed in Experiment I. The total number of correct values recalled within a problem was used as the basic score. Within the present design, the scores for the two problems which occurred within a given SET were summed and used as a single observation. The summary of the analysis of variance of the data is found in Table 15.

Main effects attributable to Complexity and Condition of Recall were not significant. The main effect attributable to SET was statistically significant ($F = 12.10$, $df = 2/88$, $p < .01$). Since SET involved repeated measures across three instance exposure intervals, the conservative test was applied. Under the test, the effect was again statistically significant ($F = 12.10$, $df = 1/47$, $p < .01$). No interactions were found to be significant sources of variation.

As indicated from inspection of Table 16, the mean number of values recalled was 28.40, 30.75, and 31.85 for the 5, 10, and 15 second conditions respectively. Subsequent orthogonal polynominal analysis indicated that the linear component was significant ($F = 23.46$, $df = 1/44$, $p < .01$). Thus it was concluded that recall performance increased as a positive function of the amount of time available for viewing the instances.

**Category Retention**

Recall of categories was evaluated on the basis of the total number of categories recalled within a problem. This scoring system yielded a maximum of five correct category responses for any given problem. Within the design employed, the category performance scores for each *S* were summed across the two problems presented within each SET condition. Table 17 summarizes the analysis of variance of this data.

The single effect found to be significant was attributable to SET ($F = 4.82$, $df = 2/88$, $p < .05$). Under the conservative test ($df = 1/47$), the effect was again found significant.

Inspection of Table 18 indicates that the mean number of categories recalled for two problems were 7.98, 7.88, and 8.65 within the 5, 10, and 15 second conditions respectively. Subsequent analysis of this main effect involved an orthogonal polynominal analysis and indicated that the linear component was significant ($F = 6.30$, $df = 1/47$, $p < .05$). Thus, the number of categories recalled generally increased with increasing amount of stimulus exposure time.

Table 17. Summary of Analysis of Variance of Number of Categories Recalled

| Source | df | MS | F |
|---|---|---|---|
| Complexity (C) | 1 | .02 | < 1 |
| Recall (R) | 1 | 12.25 | 2.50 |
| C x R | 1 | .89 | < 1 |
| Ss (C x R) | 44 | | |
| SET | 2 | 8.40 | 4.82* (c)* |
| Linear 1 | | 10.95 | 6.30* |
| Quadratic 1 | | 5.85 | 3.36 |
| C x S | 2 | 2.39 | 1.37 |
| R x S | 2 | 3.27 | 1.87 |
| C x R x S | 2 | 1.51 | < 1 |
| Ss (C x R) | 88 | 1.74 | |
| Total | 143 | | |

*$p < .05$

Table 18. Mean Number of Categories Recalled for all Treatment Groups

| Conditions of Recall | Concept Complexity | Stimulus Exposure Time (SET) 5 Seconds | 10 Seconds | 15 Seconds | Complexity Means | Recall Means |
|---|---|---|---|---|---|---|
| Unrestricted | 1-Value Relevant (8.36) | 7.7 | 8.3 | 9.1 | 1-Value (8.18) | Unrestricted (8.46) |
| | 3-Values Relevant (8.56) | 8.3 | 8.5 | 8.8 | | |
| Random | 1-Value Relevant (8.00) | 7.83 | 7.83 | 8.3 | 3-Values (8.15) | Random (7.88) |
| | 3-Values Relevant (7.75) | 8.1 | 6.8 | 8.3 | | |
| SET Means | | (7.98) | (7.88) | (8.65) | | |

## SUMMARY

A summary of the three analyses of variance is found in Table 19. In the present experiment, contrary to prediction, Concept Complexity was again found not to differentially affect either concept identification or the recall of instance values and categories. Also, Conditions of Recall as a main effect was found nonsignificant. However, the direction of the means was similar for recall of both instance values and categories; namely, that the unrestricted recall condition was associated with more efficient recall of both values and categories. Partial support of the hypothesis concerning Conditions of Recall seems therefore justified.

As hypothesized, the recall of both instances and values was found to be positively associated with increasing amounts of exposure time. For both values and categories, this relationship was found to be primarily linear. Further, concept identification was also related to SET but the specificity of the relationship was obtained only where Conditions of Recall were considered. Under the random recall condition, increasing amounts of exposure time were related to increasing efficiency of concept identification. Within the unrestricted recall condition, however, concept identification was not apparently facilitated beyond the 10 second SET.

These results, along with the results of the first experiment provide partial bases for inferring that an increase in memory requirements during concept identification decreases the efficiency with which concepts are identified. The results of this experiment will be more fully discussed in Chapter VI after the next experiment is presented.

Table 19. Summary of Analyses of Variance for Experiment II

| Main Effects | Dependent Variables: Concept Identification F | Concept Identification Direction of Mean | Instance Retention F | Instance Retention Direction of Mean | Category Retention F | Category Retention Direction of Mean |
|---|---|---|---|---|---|---|
| Concept Complexity (C) | < 1 | | < 1 | | < 1 | |
| Condition of Recall (R) | < 1 | | | Un > Rd | | Un > Rd |
| Stimulus Exposure Time (S) | | 10 > 5, 15 | 12.10** | 10, 15 > 5 | 4.82* | 15 > 5, 10 |
| Interactions | | | | | | |
| C x R | < 1 | | < 1 | | < 1 | |
| C x S | < 1 | | | | | |
| R x S | | | < 1 | | | |
| C x R x S | < 1 | | | | < 1 | |

*$p < .05$ **$p < .01$



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## V

## EXPERIMENT III

The results of the two previous experiments indicated that method of presentation, conditions of recall, and stimulus exposure time significantly influenced the recall of instance values and categories. Superior recall resulted when instances were simultaneously presented and when the instances were displayed for longer temporal durations. Also, recall was more efficient under the non-ordered recall condition. Moreover, concept identification was, in general, found superior under these same conditions indicating that the conditions that facilitated retention also facilitated concept identification.

These results suggest that, within the conditions of the first two experiments, memory was of greater importance in concept identification then that assumed by the limited memory model (Bower & Trabasso, 1963; and Restle, 1962). Moreover, using a simulated concept identification task, Trabasso and Bower (1964) found that *Ss* recalled an average of less than one value of the six presented within each instance, whereas in the preceding experiments a higher percent of the values were recalled. The purposes of the present experiment, therefore, were twofold: first, to further investigate the effects of both stimulus availability variables employed separately in the first two experiments (method of presentation and stimulus exposure time); and second, to further determine the generality of that aspect of the limited memory assumption pertaining to the recall of instance values as tested by Trabasso and Bower. The resulting modifications in both stimulus materials and procedures will be noted subsequently. These modifications, however, permitted a more direct comparison of results between the present experiment and those found by Trabasso and Bower as well as allowing further comparisons of the variables employed within a task similar to that used in Experiments I and II but involving a greater number of total dimensions and a greater number of instances used to present the concepts.

The specific hypotheses tested in the present experiment were as follows:

1) that concept identification and the recall of instance values and categories would be more efficient under a 15 second exposure time than under a 5 second exposure time.
2) that concept identification and the recall of instance values and categories would be superior under a simultaneous rather than a successive method of presentation.

### METHOD

#### Subjects

Thirteen males and 67 females, ranging in age from 18 through 27 years (mean = 22.02 years), participated in the present experiment. The 80 *Ss* were selected on a voluntary basis from three introductory educational psychology classes which met during the second semester 1967, at the Madison campus, University of Wisconsin.

#### Experimental Materials

The stimulus materials used were geometric figures drawn on 3" x 5" index cards. Each figure was a unique combination of the following six bivalued dimensions:

number of figures ..... one or two
color of figures ..... red or blue
size of figures ..... large or small
shape of figures ..... triangular or rectangle
position of figures ..... right or left
orientation of figures ... upright or tilted

The preparation of the stimulus cards was identical to that employed with the four-dimension set. The addition of the two dimensions, however, increased the card population to 128 instance cards (64 YES, 64 NO).

Table 20. Experimental Design for Experiment III

| Stimulus Exposure Time / Problems | 5 Seconds | | | | | | | | | | | | 15 Seconds | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Method | | | | | | | | | | | | | | | | | | | | | | | | |
| Simultaneous | $S_1$ ... $S_{20}$ | | | | | | | | | | | | | | | | | | | | | | | |
| Successive | | | | | | | | | | | | | $S_{61}$ ... $S_{80}$ | | | | | | | | | | | |

The procedures used in determining the concepts to be identified were also identical to those employed with the four-dimension set with the exception that only one-value relevant concepts were used in the experiment. Each of the twelve values specified above was used as the concept. The twelve concepts are completely illustrated in Miller (1967).

Since the retention task was performed only under random recall, the test booklets contained twelve randomized sequences of seven instances each. The test booklets used for each experimental session contained different orders of the twelve sequences. This procedure resulted in each *S* recalling a different instance during any given response interval.

#### Apparatus

The apparatus was again identical to that employed in the first two experiments. The single modification involved the use of all seven apertures to accommodate the seven instances of each problem displayed under the simultaneous condition.

#### Experimental Design

A 2 x 2 x 12 factorial design, indicated in Table 20, was employed with two levels of stimulus exposure time (5 or 15 seconds), two methods of instance presentation (simultaneous or successive), and 12 problems on which repeated measures were obtained. All *S*s were run in groups of five and randomly assigned to one of the four major treatment groups. Each five-member group identified 12 concepts in randomized order.

#### Experimental Procedure

The procedure used in the present study was similar to that of Experiments I and II. Each five-subject group heard a taped set of instructions which presented the same procedural information as that used in the first two experiments. The practice concept was selected at random from the twelve experimental concepts and presented with a different instance sequence order than when it appeared as an experimental concept. In addition, the practice concept was presented under the same method by SET condition in which the *S*s were performing.

The instance presentation procedures were also similar to those employed in the first two experiments. For the successive 5-second treatment condition, each instance was displayed for five seconds with a five-second interstimulus interval. Similarly within the successive 15-second condition, instances were displayed for 15 seconds with a five-second interstimulus interval. For the simultaneous 5- and 15-second conditions, all instances were displayed for 65 and 135 seconds respectively. For all groups, 10 seconds was

Table 21. Analysis of Variance of Identified Concepts

| Source | | df | MS | F |
|---|---|---|---|---|
| SET | (S) | 1 | 7.00 | 4.96* |
| Method | (M) | 1 | 3.75 | 2.65 |
| S x M | | 1 | 1.20 | < 1 |
| *Ss* (SM) | | 76 | 1.41 | |
| Ordinal Position | (O) | 11 | .27 | 3.00** (c)NS |
| S x O | | 11 | .08 | < 1 |
| M x O | | 11 | .06 | < 1 |
| S x M x O | | 11 | .06 | < 1 |
| *Ss* (SM) | | 836 | .09 | |
| Total | | 959 | | |

* $p < .05$ ** $p < .01$

Table 22. Mean Number of Concepts Identified for all Treatment Groups

| Stimulus Exposure Time | Method of Presentation | Ordinal Position of Problem 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Method Means |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 Seconds (.610) | Simultaneous (.637) | .70 | .55 | .60 | .60 | .65 | .70 | .55 | .65 | .75 | .55 | .65 | .70 | Simultaneous (.758) |
| | Successive (.583) | .60 | .55 | .55 | .45 | .45 | .55 | .55 | .70 | .65 | .60 | .65 | .70 | |
| 15 Seconds (.781) | Simultaneous (.879) | .90 | .80 | .65 | .90 | .90 | .90 | .90 | .90 | .95 | .90 | .90 | .95 | Successive (.633) |
| | Successive (68.3) | .80 | .65 | .55 | .60 | .70 | .70 | .65 | .65 | .75 | .70 | .75 | .70 | |
| Ordinal Position Means | | .751 | .637 | .587 | .637 | .675 | .712 | .662 | .725 | .775 | .688 | .737 | .762 | |

allowed for completing the description of the concept and 15 seconds for the recall of each instance.

### Treatment of the Data

The three dependent variables used to assess performance were number of concepts correctly identified, number of instance values recalled, and number of instance categories recalled. Each dependent variable was tested within a 2 x 2 x 12 repeated measures analysis of variance. The probability of a Type I error was set at the .05 level. Effects significant beyond the .01 level were reported as such. Where feasible, statistically significant effects were tested by post mortem means comparisons tests and/or via orthogonal polynomial analyses.

## RESULTS

### Concept Identification

The same scoring system as previously described was employed to assess concept identification. For each of the four main treatment groups, 20 *Ss* received twelve problems. The summary of the analysis of the data is found in Table 21. The mean number of concepts identified for each of the 48 total cells is found in Table 22.

Table 23. Analysis of Variance of Number of Recalled Values

| Source | | df | MS | F |
|---|---|---|---|---|
| SET | (S) | 1 | 3,619.27 | 21.16** |
| Method | (M) | 1 | 653.40 | 3.82 |
| S x M | | 1 | 752.60 | 4.40* |
| *Ss* | | 76 | 171.00 | |
| Ordinal Position | (O) | 11 | 136.73 | 6.93** (c)* |
| Linear | 1 | | 966.52 | 48.99** |
| Quadratic | 1 | | 233.82 | 11.85** |
| Residual | 9 | | 33.72 | 1.71 |
| S x O | | 11 | 25.53 | 1.28 |
| M x O | | 11 | 27.02 | 1.36 |
| S x M x O | | 11 | 12.33 | < 1 |
| *Ss* (SM) | | 836 | 19.73 | |
| Total | | 959 | | |

*$p < .05$ **$p < .01$

The main effects found to be significant were SET ($F = 4.96$, $df = 1/76$, $p < .05$) and Ordinal Position ($F = 3.00$, $df = 11/836$, $p < .01$). Under the conservative test ($df = 1/79$), however, the Ordinal Position effect was found to be nonsignificant.

The two means involved in the significant SET main effect were .610 and .781 for the 5 and 15 second conditions, respectively. Thus 61.0% and 78.1% of the concepts were correctly identified within each of the two SET conditions. Moreover, inspection of Table 22 indicates the stability of the effect of the two SET conditions across both method and ordinal position.

Although the method of presentation was not statistically significant at the .05 level, the means were in the hypothesized direction. Under the simultaneous method an average of .785 concepts were identified; the mean for the successive presentation was .633.

Although the effect of Ordinal Position was found nonsignificant under the conservative test, it may be instructive to observe the mean number of concepts identified across the 12 problems. As indicated by Table 22, no consistent performance trends occurred as a result of practice. Moreover, the relatively small variability of the means across Ordinal Position would suggest a general ceiling effect produced by the conditions of the experiment.

**Instance Retention**

The recall of instance values was assessed in the same manner as in Experiments I and II. The scoring procedure yielded a maximum of 42 recalled values for any given concept. The summary of the analysis of variance of the data is found in Table 23.

Significant main effects included SET ($F = 21.16$, $df = 1/76$, $p < .01$) and Ordinal Position ($F = 6.93$, $df = 11/836$, $p < .01$). Since the effect of Ordinal Position involved repeated measures across 12 problems it was retested against the critical value specified under the conservative test ($df = 1/79$, $p < .05$). The interaction of SET with method was also found a significant source of variability ($F = 4.40$, $df = 1/76$, $p < .05$).

As indicated by inspection of Table 24 the mean number of recalled values was 29.25 and 33.14 for the 5 and 15 second conditions, respectively. Moreover, the performance superiority of the *Ss* within the 15 second condition was evidenced across all ordinal positions. Thus, within the conditions of the present experiment, it may be concluded that the number of values recalled was, in part, dependent upon the amount of time that the instances were available for inspection.

Figure 3 illustrates the significant SET by Method interaction. Subsequent analysis of the interaction involved means comparisons within each level of method across the two SET conditions. It was found that recall significantly increased within the simultaneous condition as SET increased from 5 to 15 seconds ($t = 4.71$, $df = 76$, $p < .001$). Performance within the successive method did not differ significantly across the two SET conditions ($t = 1.76$). It may therefore be concluded that

Table 24. Mean Number of Values Recalled for all Treatment Groups

| Stimulus Exposure Time | Method of Presentation | Ordinal Position of Problems 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Method Means |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 seconds (29.25) | Simultaneous (29.19) | 32.45 | 31.30 | 32.40 | 29.65 | 30.55 | 29.35 | 27.10 | 27.45 | 26.65 | 27.55 | 29.30 | 26.55 | Simultaneous (32.02) |
| | Successive (29.31) | 33.25 | 31.75 | 30.05 | 28.00 | 28.40 | 29.65 | 28.20 | 28.10 | 28.85 | 28.40 | 29.75 | 27.35 | |
| 15 seconds (33.14) | Simultaneous (34.85) | 37.85 | 36.25 | 36.50 | 34.75 | 34.65 | 35.00 | 34.80 | 33.45 | 33.60 | 34.60 | 34.05 | 32.65 | Successive (30.37) |
| | Successive (31.43) | 32.40 | 31.30 | 31.10 | 30.85 | 31.10 | 31.30 | 31.95 | 31.05 | 30.40 | 31.45 | 32.70 | 31.50 | |
| Ordinal Position Means | | 33.99 | 32.65 | 32.51 | 30.81 | 31.18 | 31.33 | 30.51 | 30.01 | 29.88 | 30.50 | 31.45 | 29.50 | |

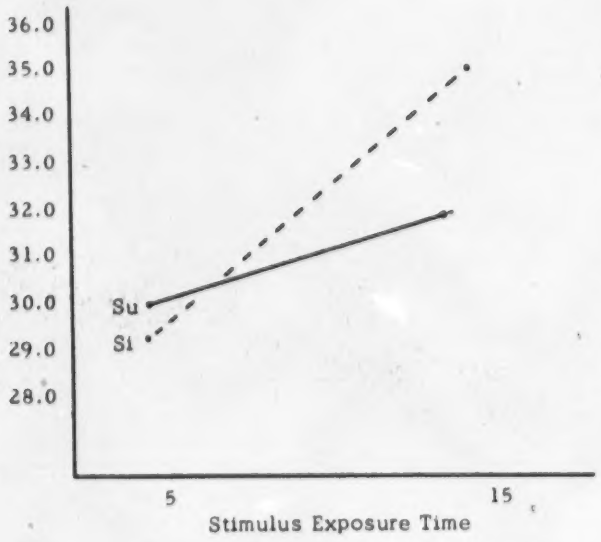


Figure 3. Mean Number of Values Recalled Within Problem as a Joint Function of Method of Presentation and Stimulus Exposure Time.

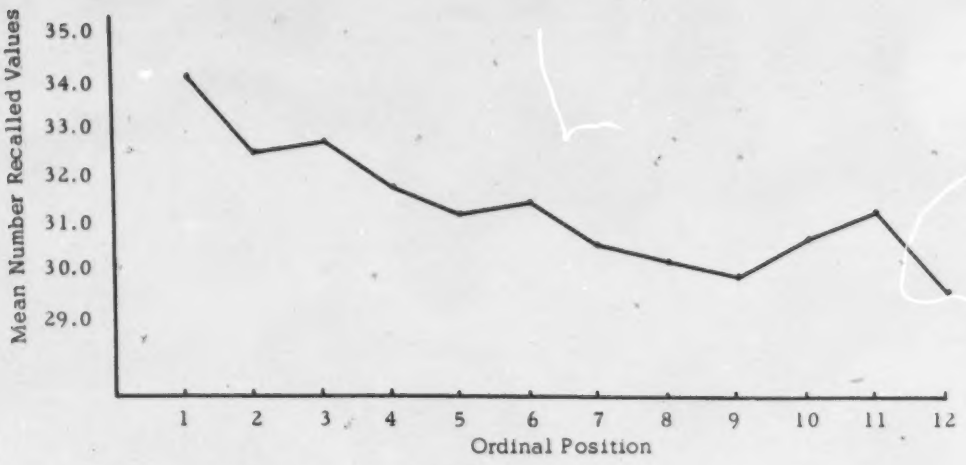


Figure 4. Mean Number of Instance Values Recalled as a Function of Ordinal Position

the source of the interaction was the differential effect of SET upon the performance of *Ss* performing within the simultaneous condition.

The interaction between method and SET further suggested a comparison of the results obtained in the present study with those reported by Trabasso and Bower (1964). Their findings suggested that *Ss* were recalling an average of less than one of the six values presented within each instance. This result, however, was based upon a scoring procedure somewhat different from that employed in the present study. Based upon a correction factor for chance performance, the average probability of recalling one of the six values was .583. The obtained probability of .567 reported by the study was therefore used to determine the number of values actually recalled.

Similar analyses were performed upon two of the treatment groups entering into the interaction. The first group (5-second successive) performed under conditions similar to those employed in the Trabasso and Bower study. The second group (15-second simultaneous) performed within the optimal conditions employed in the present study. The calculated probabilities yielded an average of 2.37 and 3.91 values recalled within each instance. Thus, it would appear that the observed differences were attributable to the two different identification tasks employed and to the levels of the variables employed in the present study.

The significant main effect of Ordinal Position is illustrated in Figure 4. Subsequent analysis of this function involved an orthogonal polynomial analysis and indicated that both the linear ($F = 48.99$, $df = 1/79$, $p < .01$) and quadratic ($F = 11.85$, $df = 1/79$, $p < .01$) components were significant. Thus, it may be concluded that the number of values recalled was primarily a negative linear function of the amount of practice on similar problems.

**Category Retention**

The number of categories recalled within each problem was again used as the basic data for the analyses. Due to the increased number of instances used to present the concept, 7 was the maximum score attainable. The summary of the analysis of variance of the category recall data is found in Table 25. Table 26 indicates the mean number of categories recalled within each treatment condition.

The main effect of SET was significant ($F = 8.00$, $df = 1/76$, $p < .01$), as were the main effects of Method ($F = 5.49$, $df = 1/76$, $p < .05$) and Ordinal Position ($F = 2.05$, $df = 11/839$, $p < .05$). When retested under the reduced degrees of freedom ($df = 1/79$), the effect of Ordinal Position was found nonsignificant.

The mean number of recalled categories was 5.73 and 6.21 for the 5 and 15 second SET conditions, respectively. Thus, 82 and 89% of the total number of categories presented were recalled. Moreover, the facilitative effect of increased exposure time upon category recall was found in both Experiments II and III.

Similarly, the mean number of categories recalled for the simultaneous and successive methods of instance presentation was 6.17 (88%) and 5.77 (83%), respectively. Thus,

Table 25. Analysis of Variance of Number of Recalled Categories

| Source | df | MS | F |
|---|---|---|---|
| SET | 1 | 57.04 | 8.00** |
| Method | 1 | 39.20 | 5.49* |
| S x M | 1 | 19.84 | 2.78 |
| *Ss* (SM) | 76 | 7.13 | |
| Ordinal Position (O) | 11 | 2.32 | 2.05* (c)NS |
| S x O | 11 | .51 | < 1 |
| M x O | 11 | .95 | < 1 |
| S x M x O | 11 | 1.13 | 1.05 |
| *Ss* (SM) | 839 | 1.07 | |
| Total | 959 | | |

*$p < .05$ **$p < .01$

Table 26. Mean Number of Categories Recalled for all Treatment Groups

| Stimulus Exposure Time | Method of Presentation | Ordinal Position of Problems 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Method Means |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 Seconds (5.73) | Simultaneous (5.78) | 5.40 | 5.50 | 5.90 | 5.95 | 5.55 | 5.75 | 5.85 | 5.50 | 5.50 | 6.30 | 6.20 | 6.00 | Simultaneou (6.17) |
| | Successive (5.67) | 5.30 | 6.15 | 5.55 | 5.25 | 5.60 | 5.80 | 5.55 | 5.65 | 5.90 | 6.00 | 5.90 | 5.40 | |
| 15 Seconds (6.21) | Simultaneous (6.56) | 6.60 | 6.70 | 6.60 | 6.45 | 6.30 | 6.65 | 6.45 | 6.30 | 6.65 | 6.80 | 6.70 | 6.50 | Successive (5.77) |
| | Successive (5.87) | 5.80 | 5.80 | 5.45 | 5.55 | 5.75 | 5.90 | 5.95 | 5.80 | 6.00 | 6.15 | 6.05 | 6.20 | |
| Ordinal Position Means | | 5.78 | 6.04 | 5.88 | 5.80 | 5.80 | 6.03 | 5.94 | 5.81 | 6.01 | 6.31 | 6.21 | 6.03 | |

the upper and lower levels of both the recall and method variables resulted in essentially the recall of similar amounts of information. Moreover, the high levels of recall evidenced under both method and SET conditions not only resulted in reduced variability of performance but also again suggested a ceiling effect produced essentially by minimal information required for near maximum category recall. These two factors were primarily the source of the finding that the two main effects operated essentially independently to produce category performance differences. Thus, the interaction of method by SET found for values failed to occur for categories.

**Primacy and Recency Effects**

Certain effects of the order of presentation upon the recall of information are relevant in the present series of experiments. Although not bearing directly on the hypotheses of the third experiment, the statistical information regarding primacy and recency effects is pre-

Table 27. Summary of Analysis of Variance of Values Recalled as a Function of Instance Presentation Order for Experiment I

| Source | | df | MS | F |
|---|---|---|---|---|
| Between *Ss* | | 79 | 24.55 | |
| Within *Ss* | | 320 | 4.64 | |
| Presentation Order | | 4 | 84.75 | 23.34** (c)** |
| Linear | 1 | | 17.28 | 4.76* |
| Quadratic | 1 | | 306.34 | 84.39** |
| Residual | 2 | | 7.69 | 2.12 |
| Error | | 316 | 3.63 | |
| Total | | 399 | | |

*$p < .05$ **$p < .01$

Table 28. Summary of Analysis of Variance Values Recalled as a Function of Instance Presentation Order for Experiment II

| Source | | df | MS | F |
|---|---|---|---|---|
| Between *Ss* | | 47 | 41.36 | |
| Within *Ss* | | 192 | 9.58 | |
| Presentation Order | | 4 | 170.35 | 27.70** (c)** |
| Linear | 1 | | 164.52 | 26.75** |
| Quadratic | 1 | | 438.08 | 71.23** |
| Cubic | 1 | | 69.42 | 11.29** |
| Residual | 1 | | 9.38 | 1.52 |
| Error | | 188 | 6.15 | |
| Total | | 239 | | |

**$p < .01$

sented at this point, rather than omitting it until the discussion of all the experiments in the last chapter of the dissertation.

Concepts are not, as a rule, learned in a single trial or as a result of a single exposure to an instance of the concept. In the present experiments, whether instances were presented simultaneously or successively, the problem structure demanded a single serial order of information processing. A number of investigators (Bourne, Goldstein, & Link, 1964; Cahill & Hovland, 1960; Hunt, 1961; and Trabasso & Bower, 1964) have reported evidence suggesting that *Ss* retain greater amounts of information when presented at the extremes in a series of instances. With the exception of the Trabasso and Bower study, however, the results were primarily based upon the degree to which *Ss'* hypotheses concerning the identity of the concept were compatible with previously presented information. It is apparent that this procedure confounds two types of possible errors—memory errors and errors resulting from *Ss'* failure to draw the correct inferences from previously presented information.

In view of the fact that retention measures were employed in the present three experiments, analyses were performed in order to determine the effects of instance presentation order upon the recall of the values within each instance. Tables 27 and 28 contain the summary of the analyses of variance on the total number of values recalled within each instance presentation position for Experiments I and II. A combined illustration of the primacy and recency effects is found in Figure 5. For the purpose of more adequately allowing between study comparisons, the metric employed is the mean percent of values recalled within instance.



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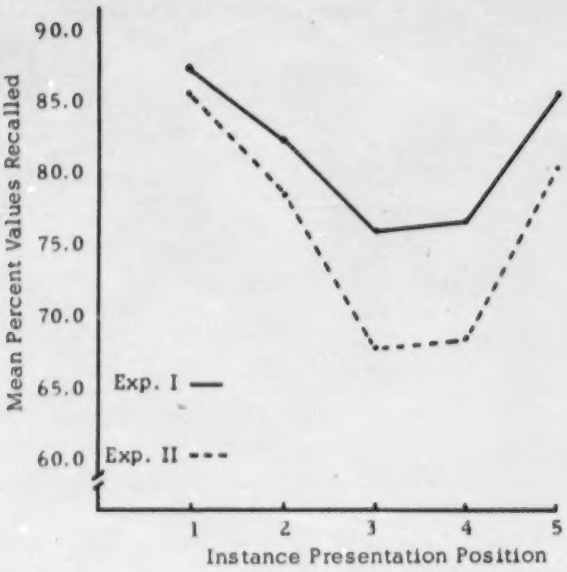


Figure 5. Mean Percent Values Recalled for Each Instance as a Function of Instance Presentation Position.

Table 29. Summary of Analysis of Variance Values Recalled as a Function of Instance Presentation Order for Experiment III

| Source | df | MS | F |
|---|---|---|---|
| Between *Ss* | 79 | 404.71 | |
| Within *Ss* | 480 | 43.97 | |
| Presentation Order | 6 | 1,492.19 | 58.19** (c)** |
| Linear 1 | | 64.74 | 2.46 |
| Quadratic 1 | | 8,667.61 | 338.05** |
| Residual 4 | | 55.20 | 2.15 |
| Error | 474 | 25.64 | |
| Total | 959 | | |

** $p < .01$

Significant main effects attributable to Instance Presentation Order were found for Experiment I ($F = 23.34$, $df = 4/316$, $p < .01$) and Experiment II ($F = 27.70$, $df = 4/188$, $p < .01$). When tested against the critical value specified by the conservative test ($df = 1/79$ and $1/47$, respectively) both effects retained their original levels of significance. Moreover, orthogonal polynomial analyses applied to each effect indicated that the number of values recalled was primarily a quadratic function of Instance Presentation Order ($F = 84.39$, $df = 1/79$, $p < .01$ and $F = 71.23$, $df = 1/47$, $p < .01$).

A similar analysis was performed on Instance Presentation Order for Experiment III. Table 29 indicates the summary of the analysis of variance of the data and Figure 6 illustrates the effect.

Again the effect of Instance Presentation Order was found significant ($F = 58.19$, $df = 6/474$, $p < .01$), and, when tested under the reduced degrees of freedom specified by the conservative test ($df = 1/79$), retained its original level of significance. Similarly, the function illustrated in Figure 6 was best described as quadratic ($F = 338.05$, $df = 1/79$, $p < .01$).

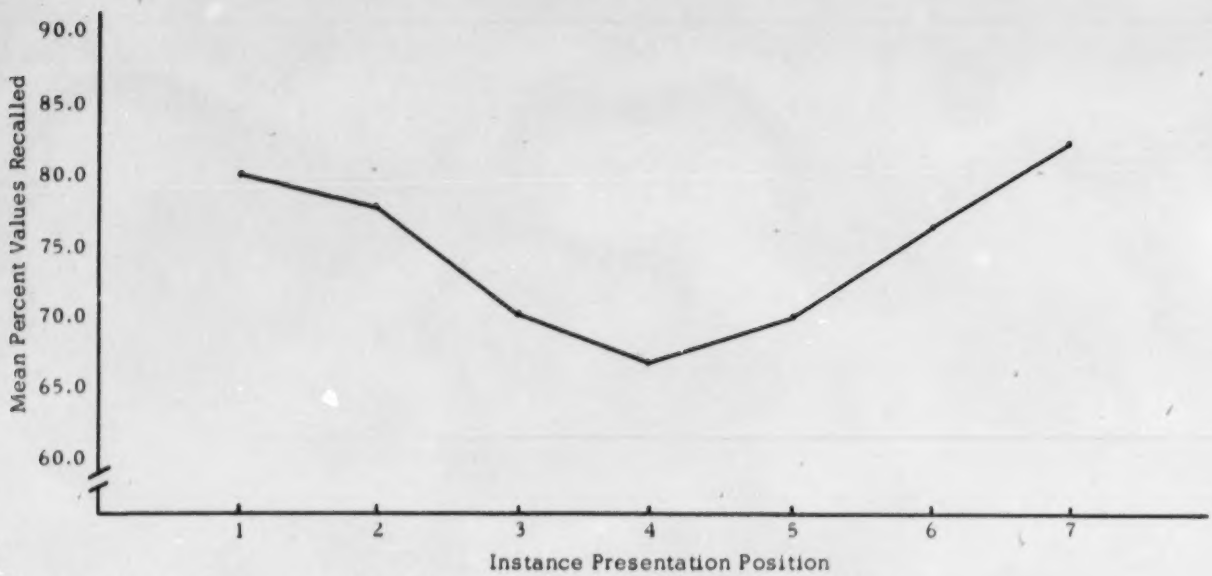


Figure 6. Mean Percent of Values Recalled for Each Instance as a Function of Instance Presentation Order.

Table 30. Summary of Analyses of Variance for Experiment III

| Main Effects | Dependent Variables: Concept Identification F | Concept Identification Direction of Mean | Instance Retention F | Instance Retention Direction of Mean | Category Retention F | Category Retention Direction of Mean |
|---|---|---|---|---|---|---|
| Stimulus Exposure Time (S) | 4.96* | 15 > 5 | 21.16** | 15 > 5 | 8.00** | 15 > 5 |
| Method of Presentation (M) | | Si > Su | | Si > Su | | Si > Su |
| Ordinal Position (O) | | | 6.93* | | | |
| **Interactions** | F | | F | | F | |
| S x M | < 1 | | 4.40* | | | |
| S x O | < 1 | | | | < 1 | |
| M x O | < 1 | | | | < 1 | |
| Se x O | | | | | | |
| S x M x O | < 1 | | < 1 | | | |

*$p < .05$ **$p < .01$

In order to further assess these functions, a Newman-Keuls post mortem means comparison test was employed. The results were as follows: Experiment I—the means of the first and fifth positions differed significantly from those of the third and fourth ($p < .01$); Experiment III—the means of the first, second, sixth and seventh positions differed significantly from those of the third, fourth, and fifth ($p < .01$). Thus it may be concluded that increased amounts of information were recalled for instances presented either early or late in a series.

## SUMMARY

As hypothesized, both concept identification and the recall of instances and categories were significantly superior under the 15 second exposure interval. The recall of categories was also found to be significantly superior under the simultaneous method of instance presentation. While not significant, both concept identification and the recall of values were found to be in the hypothesized direction; namely, a suggested increase in performance under the simultaneous condition. These results, along with the results of the first two experiments, lend further support to the hypothesis that the experimental conditions producing increased memory requirements, as measured by recall performance, also produce less efficient concept identification. A further discussion of the hypothesis is presented in the last chapter.

# VI
# SUMMARY AND DISCUSSION

## SUMMARY

Three experiments were performed to investigate concept identification and recall of information as a function of four selected variables: concept complexity (one or three values relevant); method of instance presentation (simultaneous or successive); stimulus exposure time (5, 10, or 15 seconds); and conditions of recall (unrestricted or random). In all three experiments, retention was measured by the recall of instance values and the recall of instance categories. The number correct was used as the measure of concept identification.

The *S*s used in all three experiments were selected from introductory educational psychology courses at the University of Wisconsin. The number of *S*s used in each experiment were as follows: Experiment I, 80 *S*s (19 males and 61 females); Experiment II, 48 *S*s (14 males and 34 females); and Experiment III, 80 *S*s (13 males and 67 females).

The stimulus materials used in the first two experiments were identical, consisting of geometric figures drawn on 3" x 5" index cards. Each figure contained a unique combination of four, bivalued dimensions. The dimensions and their corresponding values were: (1) number of figures—one or two; (2) color of figure—red or blue; (3) size of figure—large or small; and (4) shape of figure—triangle or rectangle. The stimulus materials for the third experiment were identical with the exception that two additional dimensions were included. The dimensions were: (1) orientation of figure—upright or tilted; and (2) position of figure—left or right.

The *S*s' task in all three experiments was identical. The *S*s viewed a series of instances which uniquely defined a concept. After the last instance was displayed, *S*s wrote their descriptions of the concept and recalled both the values and category of each presented instance. The task proceeded without interruption until the assigned number of problems was completed.

In Experiment I, two levels of method of presentation (simultaneous or successive), concept complexity (one, or three values relevant), conditions of recall (unrestricted or random), and five concept problems were factorially combined within a 2 x 2 x 2 x 5 design. Four groups of five *S*s performed on five problems within each of the eight unique treatment conditions.

The essential findings of Experiment I were:

1. Recall of both values and categories increased when all instances of the concept were presented simultaneously. Although not statistically significant, the simultaneous method of presentation was also related to more efficient concept identification.
2. Both the number of values and categories recalled increased when nonordered recall was permitted. The unrestricted recall condition was also found to be related to more efficient concept identification.
3. Concept Complexity was not found to differentially affect either concept identification or recall of instance values or categories.

In Experiment II, two levels of complexity (one or three values relevant), conditions of recall (unrestricted or random), and three levels of stimulus exposure time (5, 10, and 15 seconds) were factorially combined within a 2 x 2 x 3 design. The three stimulus exposure times were employed to ascertain how this variable would operate with the levels of complexity and conditions of recall. Four groups of three *S*s were assigned to each of the four complexity by recall treatment combinations. Within each treatment combination, each *S* performed on six problems, two within each SET level.

The essential findings of Experiment II were:

1. Both the recall of values and categories were more efficient with increasing amounts of exposure time. Concept identification was also found related to increasing amounts of exposure time under the random recall condition but not under the unrestricted recall condition.
2. Concept Complexity was not found to differentially affect either concept identification or recall of instances and categories.

Having established that both better concept identification and retention of instances were associated with a simultaneous method of presentation, a longer stimulus exposure time, and an unrestricted method of recall—three conditions associated with reducing memory requirements during concept identification—a third experiment was run to further validate the results associated with SET and the successive presentation method and also to secure further evidence regarding the limited memory assumption as tested by Trabasso and Bower (1964). Two levels of SET (5 and 15 seconds) and method of instance presentation (simultaneous or successive) were factorially combined in a 2 x 2 x 12 design. Four groups of five *S*s were randomly assigned to each of the four treatment combinations. Each *S* performed on 12 problems.

The essential findings of Experiment III were as follows:

1. Both concept identification and recall of instance values and categories were found significantly superior under the 15 second stimulus exposure duration.
2. Category recall was found to be superior under the simultaneous method of presentation. Similar, though nonsignificant, relationships were also noted for concept identification and recall of values.

## DISCUSSION

The simultaneous method of presentation, longer stimulus exposure durations, unrestricted conditions of recall and lower complexity concepts were hypothesized to facilitate both concept identification and the recall of instance values and categories. In general these independent variables functioned as hypothesized with the following exceptions: (1) that complexity did not differentially affect either concept identification or the two recall measures; and (2) that the remaining variables were found more significantly associated with recall rather than with concept identification. However, the consistency with which concept identification and recall were similarly affected by the levels of the variables specified above provides some support for the related inference to be drawn; namely, that decreasing memory requirements during concept identification facilitates the subsequent identification of the concept. A further brief discussion of the preceding points follows.

The failure of the complexity of the concept to produce performance difference across the three dependent variables of both Experiments I and II was an unexpected finding. A number of studies have found that as the amount of relevant information increases, acquisition performance decreases (e.g., Archer, 1954; Bourne, 1963). The complexity of the concepts used for the two experiments, however, was manipulated differently from the above studies in that the number of relevant to irrelevant dimensions was confounded. This was primarily for the purpose of holding constant the total number of dimensions and the number of instances used to present concepts of both complexities.

There is, however, a plausible explanation for the nonsignificant complexity effect that concerns "concept size"—the total number of relevant dimensions employed in a concept identification task. Based upon a Huttenlocher-type task, Glanzer, Huttenlocher, and Clark (1963) suggested that complexity is at a maximum when the ratio of relevant dimensions to total dimensions is one to two. The complexity manipulations employed in Experiments I and II were based upon the ratios one to four and three to four. Moreover, in both tasks, when the ratios of relevant to total dimensions is less than one-half, the NO instances provide sufficient information to identify the concept in that a NO instance indicates that the dimension just varied is relevant. In the present experiments, only one NO instance was used for one value relevant concepts. Conversely, when the ratio is over one-half, the YES instances indicate that the dimension just varied is not relevant. In the present experiments, two YES instances were used for the three-value relevant concepts. Consequently, the relative equivalence of the minimum sufficient information necessary to identify the concept may have accounted for the failure of complexity to produce performance differences.

The three dependent variables used in the two experiments which varied complexity pro-

vided the data to partially test this assumption. Within each experiment, the frequency with which the presence or absence of the minimum sufficient information occurred with the identification or nonidentification of the concept was compared within each complexity level. The frequencies were tested within 2 x 2 contingency tables by Chi-square analyses. The results were as follows: Experiment I, one-value relevant concepts ($\chi^2$ = 12.97, $df$ = 1, $p < .001$); Experiment I, three-value relevant concepts ($\chi^2$ = 6.41, $df$ = 1, $p < .05$); Experiment II, one-value relevant concepts ($\chi^2$ = 4.66, $df$ = 1, $p < .05$); and Experiment II, three-value relevant concepts ($\chi^2$ = 7.11, $df$ = 1, $p < .01$).

The significant Chi-square values indicated that dependencies existed between the recall of the minimum sufficient information necessary to identify the concept and the frequency with which concept identification occurred. Moreover, these dependencies were found within each complexity level and for each experiment. Therefore, it may be tentatively suggested that the *S*s performing within both complexity levels were using relatively equivalent amounts of information to identify the concepts consequently making the two complexity manipulations equivalent.

The remaining three independent variables employed in the present study were found more significantly associated with recall rather than concept identification. Thus, the results tend to provide support for the inference that simultaneous methods of presentation, unrestricted conditions of recall, and longer exposure intervals reduced memory requirements as evidenced by greater recall efficiency found under these conditions.

The finding that simultaneously presented instances generally resulted in more efficient retention provides substantial support for similar conclusions based upon less adequate retention measures made by other investigators (e.g. Cahill & Hovland, 1960; and Bourne, Goldstein, & Link, 1964). It may suggested that this finding may reflect the degree to which flexible processing strategies were available to *S*. Within the simultaneous method both interdimensional (within instance) and intradimensional (between instance) processing alternatives could be employed. Moreover, the simultaneous method allowed *S* to view both the problem and the problem structure as a whole which may have allowed faster and more precise concept identification to occur. The successive method, however, allowed only interdimensional information processing and required that *S* retain previously presented information which was no longer available for inspection in order to adequately identify the concept.

It may also be observed that a similar interpretation may be offered for the observed differences in performance due to conditions of recall. Under the unrestricted recall conditions, both interdimensional and intradimensional retrieval alternatives were available. The randomized recall task, however, placed a premium upon immediate availability of the sequence position of each instance and allowed only interdimensional retrieval. If correct, this interpretation suggests not only the critical nature of the retention task per se, but also that recall is most efficient when maximum utilization of available sequential and dimensional cues is allowed. This position is somewhat similar to that taken by a number of investigators who have employed a wide variety of experimental techniques and tasks (e.g. Bousfield, Puff, & Cohen, 1964; and Tulving, 1966).

It may be argued that supportive, though not crucial, evidence for this interpretation would be found in a significant method by recall interaction (Experiment I) in which differentially more efficient recall was found for the simultaneous-unrestricted condition, or, conversely, less efficient recall performance for the successive-random condition. Such an interaction did not occur. However, inspection of the recall performance across all treatment conditions of Experiment I indicated that the mean number of values and categories recalled was near maximum. Thus, it may be suggested that, within the conditions of Experiment I, the relatively small amount of information presented produced a high but limited recall performance range making such an interaction unlikely. Consequently, within the confines of the task and techniques used in the present experiments, the problem of the degree to which method and recall produce differences in either reception or retrieval strategies must await future empirical validation.

The recall of greater amounts of information was also found a function of longer exposure times. Moreover, the importance of this variable was indicated both in Experiment II, when conjoined only with the successive method of presentation, and in Experiment III, when levels of both stimulus availability variables were employed. However, the finding (Experiment III) that exposure time produced significantly greater recall of values only when instances were simultaneously displayed suggests two additional interpretations. First,

under the lower SET level, time was the critical factor which produced a ceiling effect upon the amount of information to be processed regardless of the method used to present the instances. Second, only when exposure time was increased beyond the critical 5 second duration, did the method which allowed maximum organization for recall facilitate retention. This explanation receives some support from a similar conclusion reached by Bourne, Goldstein, and Link (1964). Also noted, was that concept identification, though nonsignificant, indicated a similar relationship to both variables.

In general, the results of all three experiments failed to support the limited memory assumption concerning the retention of information presented during the task. Recall of both values and categories remained at a level higher than that predicted throughout all three experiments. Moreover, the significant primacy and recency effects found for all three experiments suggest that *Ss* retained information presented early or late in a series of defining instances equally well. While the recency effect is predicted from the limited memory assumption, the primacy effect is not. Thus it is suggested that, within the conditions and task employed in the present experiments, the limited memory assumption as it pertains to the recall of information presented during the task was not supported.

Perception, learning, inferences, and memory are essential prerequisites of concept identification. In a gross way, the present series of experiments have attempted to provide bases upon which stronger inferences may be drawn concerning the role of memory in a concept identification task as a function of four variables. Based upon the results of the three experiments the following two inferences seem warranted: (1) that the variables employed, with the exception of concept complexity, were effective in producing differential memory requirements in a concept identification task; and (2) that, in general, as memory requirements were increased, concept identification correspondingly decreased.

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